VOLUME LVIII NUMBER 5 WHOLE 511

SCHOOL SCIENCE AND MATHEMATICS

MAY 1958

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Additional entry at Oak Park, Illinois, January 18, 1957. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

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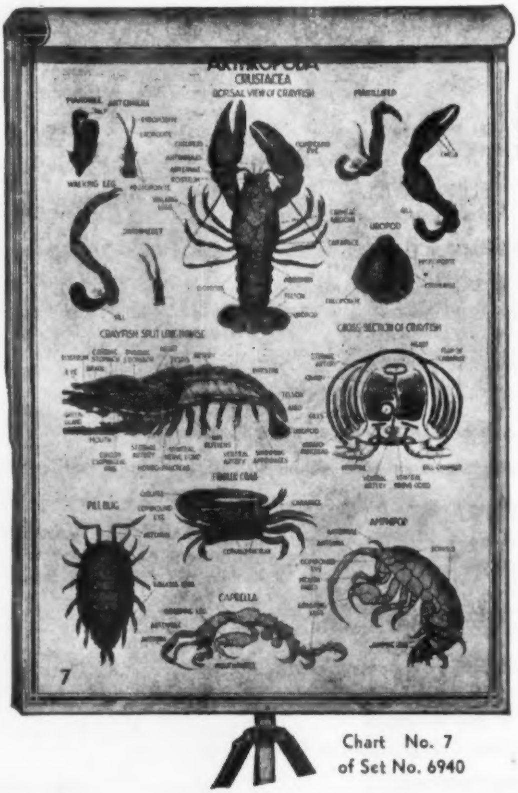

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SCHOOL SCIENCE AND MATHEMATICS

VOL. LVIII MAY, 1958 WHOLE NO. 511

RANKING OBJECTIVES IN MATHEMATICS

BROTHER T. BRENDAN, F.S.C.
Saint Mary's College, St. Mary's College P. O., California

Some excuse is certainly called for in offering ***another*** list of "aims and objectives." After all, such lists abound in the literature. It seems that every education text discusses them; every curriculum study starts with a reconsideration of them. Nevertheless, it is precisely in this connection that the following list resulted—one, it is hoped, with distinctive features worth the attention of teachers and administrators.

When I was recently appointed to a curriculum subcommittee and asked to enumerate the objectives of mathematics for high schools, I first examined several of the available lists in the hope of saving myself the work of organizing my own. None of the lists I found was satisfactory. Two defects marred almost every one of them: they did not express what I regarded as an adequate philosophy of education, and, when they did rest on a fairly sound basis, they still did not attempt to rank the various objectives in the order of their importance. That is to say, they showed a lack of pattern and hierarchy, as well as a lack of completeness.

In submitting a report to my subcommittee I resolved to have a list which would occupy a clear position, philosophically speaking, and at the same time would manifest the relative importance of the various objectives proposed. Also, I wanted to offer a brief justification for each item enumerated. The final report was modified somewhat in committee, and, with some urging from experienced high school teachers, I present it here in the following form.

I

(1) Holding first rank among the objectives is this: *the attainment of truth*. Now it is apparent that this assertion stems from a philosophy of mathematics and a philosophy of education neither of which is universally accepted: the former says that there really exists mathematical truth; the latter says that the chief concern of academic education is not pragmatic or social but intellectual. This is not the place to defend either thesis. For such a defense there is abundant literature available; I refer the reader, for example, to Edward Maziarz's *The Philosophy of Mathematics* (Philosophical Library, 1950) and to the 1943 Terry Lectures delivered at Yale by Jacques Maritain (published as *Education at the Crossroads*). The point is that we study mathematics to learn truths about discrete and continuous quantity, taken abstractly. We do not do this as does the metaphysician or ontologist—to learn the nature of quantity—but to learn its principal properties and their inter-relations. That is to say, Bertrand Russell or the Formalists to the contrary, we are *not* engaged in a mere game of postulates. As a distinguished professor once told me, "Mathematics is more than a game; there is a real responsibility to the truth in it." Of course, the truths we learn may be of a low order when measured against the wisdom that is our ultimate aim, but they do have the dignity of truth and they do contribute to acquiring that wisdom. They hold the first place in our study of mathematics.

(2) Second, in order to achieve the first objective, we have the further objective of *mastering the methodology of mathematics*. We must acquire the techniques for proving and solving. Again, this means we must learn the appropriate symbols, the nomenclature, the whole language. This is a large order, but it entails still more: we would like, even at the high school level, to begin to see the over-all structure of mathematics (as well as its isolated truths)—how it is built, its deductive nature, its applicability to the concrete, yet at the same time its generalizing and abstracting tendencies. Perhaps we can then come to recognize what is strictly scientific and what is merely dialectical in modern mathematics, and so to appreciate not only its power and scope but also its limitations in method and content.

(3) Third, we try for a *disciplinary effect* on the mind, on the imagination, and perhaps on the will. This is a direct outcome of both the first and second objectives mentioned above. That is to say, not only does the attainment of the second objective (mastering methodology) discipline the mind, but so does attainment of the first objective (grasping mathematical truth). For discipline is more than facility. Mental gymnastics are fine; the perpetual search for truth is good

exercise; but the actual possession of truth itself is formative too. This is a point well explained by Maritain in the lectures referred to (*op. cit.*, pp. 51–55). And it is a point which needs explaining since it is scarcely recognized in current educational philosophy.

Under this third objective, to be more specific, we list such subobjectives as: orderliness, accuracy, concentration, efficiency, perseverance, humility, and the like. More proper to mathematics, however, are the virtues of analytical penetration and intellectual power. In a subject where we can actually compel the assent of others, intellectual power is certainly developed. This is part of the fascination of mathematics—but it is achieved by our students only if we give them a chance. Our objective here is to encourage a sense of mastery and accomplishment by stimulating the personal solution of challenging problems. We all know how experiences of this kind engender real enthusiasm.

In this matter of intellectual training we might point out the particular advantage that mathematics has over other subjects in the high school curriculum. As one of the lists that I consulted observed, "It isolates argument from passion in a way that is unique." Mathematics has a minimum of semantic confusion. Moreover, as Aristotle mentions, it demands almost nothing in the way of experiment or experience and so is especially valuable to those who are being initiated into the arts of logic but who do lack experience. That is to say, mathematics is especially valuable to young people of high school age.

Another clarifying observation at this point: in the pursuit of rigor and discipline there are possible by-products which are *not* our objectives. We do not want to produce a hatred for mathematics nor, on the other hand, too high a regard for the subject. It is reported that Blaise Pascal hesitated to introduce his adolescent son to mathematics because of the danger of his becoming totally absorbed in the subject. In our high schools *l'esprit de géométrie* is not the only one we want to communicate.

(4) Fourth in the order of importance, it seems to me, is the objective of teaching mathematics so that it will *help our pupils in their other subjects*, whether in the higher sciences such as nuclear physics, or in lower activities such as consumer buying. E. T. Bell's classic aphorism summarizes the situation: "Mathematics is the language most adequate for idealizing the complexity of nature into apprehensible simplicity." And mathematics is more than a tool, it is also a sort of negative guide. In the words of the British mathematician, W. Sawyer, "What is not true in mathematics cannot hold in physics."

In modern times, certainly, mathematical illiteracy is a growing

handicap. Unless our pupils master some of the symbols and methods of mathematics they will be unable to cope with some of the simplest situations that arise in our complex civilization. Hence part of our teaching effort must be directed to supplying useful and appliable, as well as "pure," parts of the subject. We hope that our pupils won't bemoan their "lack of math" when they come to face the ordinary quantitative problems of life. And when they face the extraordinary quantitative problems, we hope they will be able to understand and communicate with the experts whom they call in. We hope the language of mathematics will not be a complete mystery to our students.

(5) In fifth and last place I group those objectives which we generally call *cultural*. These are personal as well as social. Taking mathematics should be an experience for our students which contributes importantly to their own self-guidance. In this subject matter, as one list puts it, we "discover the dimensions of our skills." These skills may be both creative and critical, since mathematics demands both.

Not only, however, do we want to understand ourselves, we also want to understand our civilization. The history and present position of Western culture is measured in an often unsuspected degree by mathematics. And we should try to understand mathematicians too; it is important for the layman today to realize the power and importance of the mathematician, also to understand what makes him the kind of man he is, how it is as much the beauty of his subject as its power that shapes his mind and outlook.

II

A list of aims and objectives usually contains much more specific items than the five broad purposes outlined above. In reporting to my committee I attempted to add a few more immediate, year to year, aims in our teaching.

Thus, it seems clear that first of all we must mention *arithmetic*. In so far as elementary education fails to supply our pupils with the basic numerical skills, it is our aim to make up the deficiency. This is a corollary to the list of main objectives above. And if we can extend the area of our effort to include some understanding of the structure of the number system then so much the better.

When we come to *algebra*, the immediate aims are clear—and adequately listed in almost every teacher's manual. It is important to emphasize here, just as in geometry, the postulational basis and deductive nature of algebra. At least during second-year algebra we should aim to do so. The associative, commutative, and distributive laws should be used consciously, consistently, and often. It goes without saying, of course, that abstraction and symbolization begin

here in earnest. In algebra we begin to see mathematics as a language. Moreover, it is a language which we learn to translate—let us not imitate the "successful" algebra teacher of my acquaintance whose "success" depends in part on skipping all word problems in the text!

It is probably in *geometry* that we give our pupils their first taste of mathematical rigor, their first examples of genuine deductive science, their first realization of the meaning of proof and verification, their first understanding of the importance and position of definitions and axioms in mathematics. Probably, too, our pupils get here for the first time the thrill of intellectual creativity—whether by constructions or by proofs of their own. It is understood, of course, that just as in algebra we do not have as aim mere formula-solving, so in geometry we do not have as aim mere drawing of designs or building of models.

The aims of *trigonometry* are generally given as follows: to fix and apply our algebra and geometry, to master some of the computational tools of applied mathematics; to introduce some of the transcendental functions of importance in analysis and the vector methods of importance in physics. We do *not* aim to produce mere table-searchers and triangle-solvers.

Lastly, the *other topics* taught in high school will aim chiefly, it seems to me, at arousing enthusiasms and broadening horizons, at increasing the usefulness for the terminal student of his high school mathematics, and perhaps at giving the prospective college student advanced status. For both teachers and pupils these other subjects will provide guidance information. From various quarters the following are urged: statistics, number theory, set theory, game theory, analytical geometry, calculus, and several more.

ELECTRICALLY CONDUCTING FILM COATING INVENTED

Break a transparent window and a burglar alarm sounds; drive or fly through snow with clear windshields; or walk in weather 60 degrees below zero Fahrenheit without your protective goggles fogging. These are but a few of the promises made possible by an electrically conducting coated glass designed for Libbey-Owens-Ford Glass Company of Toledo, Ohio.

The electrically conducting glass is made so with a coating of a metal and silica. The coating, which can also be applied to ceramics, can be used to produce light transmissive electrically conducting optical articles such as lens, a window or a windshield, or for space heaters, static dissipators, light transparent radio frequency shields and flat conductors.

In addition to the film's ability to adhere to glass, the layer may be accurately controlled as to electrical resistivity both in extremely low and extremely high ranges.

The film is produced by concurrently depositing by thermal evaporation on a surface within a vacuum a molecular mixture of a metal such as gold or chromium and a dielectric of an oxide of silicon.

VARIABLE HIGH VOLTAGE DC SUPPLY

(SIXTH IN A SERIES)

HARALD C. JENSEN
Lake Forest College, Lake Forest, Illinois

It is often desirable to have a compact variable high-voltage direct-current supply available for use when demonstrating electronic devices or performing measurements involving components of electronic circuits. For example, the simple cathode ray tube apparatus described in a previous issue of this JOURNAL[1] can be energized with just such a device

The supply, pictured in Figure 1, is operated from the regular 60-cycle 120-volt ac line It may be plugged directly into the line if the maximum output is needed If a variable output is desired, then the supply may be connected to a variable auto-transformer[2] which is in turn connected to the line

As indicated in Figure 1, a voltmeter, two binding posts, and a toggle switch are mounted on the front panel. An appropriate size for this panel is five by seven inches. The remaining components of the supply, two selenium rectifiers and two electrolytic capacitors, are mounted in any convenient manner on the chassis to which the panel is attached. Material used for the panel and chassis need not be metal. Wood, bakelite, masonite, etc. are completely satisfactory.

Table 1 gives a list of the components[3] and their specifications. None of these specifications are critical except the input voltage rating of the rectifiers and the working voltage of the capacitors. The former must be at least 130 volts and the latter at least 200 volts. The 0–500 rating for the voltmeter is the lowest commonly available and still compatible with the maximum output (approximately 380 volts) of the supply. The only criterion used for the selection of 60 milliampere rectifiers is one of cost. The current suggested is sufficient for many purposes.

Electrical connections are shown in Figure 2. The diagram should not be difficult to follow. However, polarity of the electrolytic capacitors must be carefully observed. The positive terminal of the capacitor C_1 must be connected to the cathode k of rectifier R_1 and the positive terminal of capacitor C_2 must be connected to the negative terminal of C_1. It must also be noticed that the cathode k of R_2 is connected to the anode of R_1.

The principles involved in the operation of the circuit are discussed

[1] H. C. Jensen, SCHOOL SCIENCE AND MATHEMATICS, April 1957.
[2] Variac or Powerstat.
[3] Available from suppliers of radio or electronic parts.

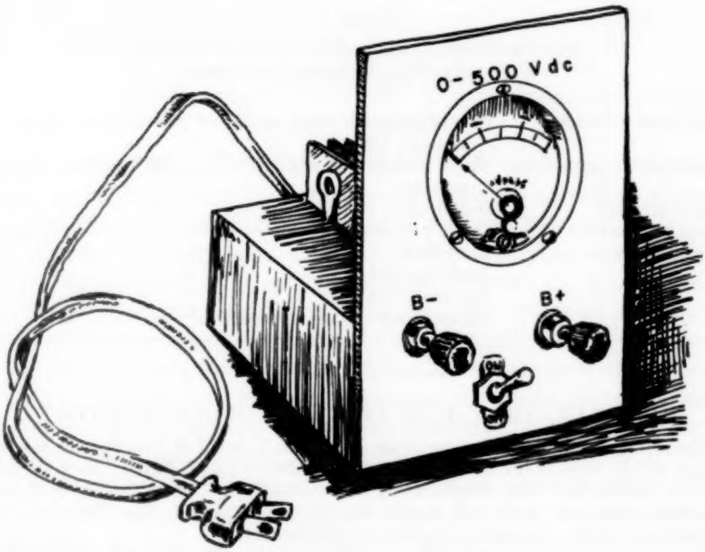

FIG. 1. Sketch showing construction features of variable high voltage dc supply.

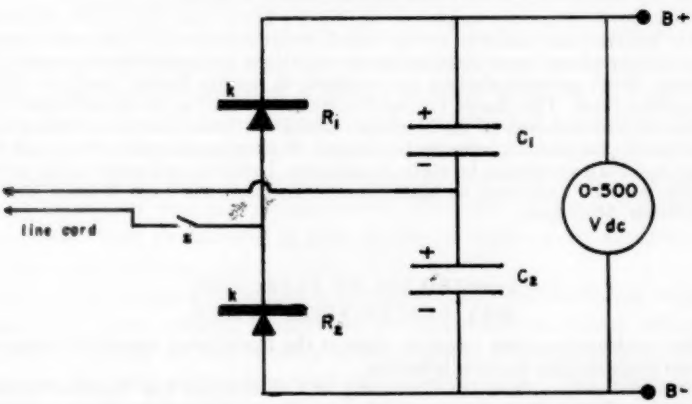

FIG. 2. Diagram of the circuit connections for variable high voltage dc supply. R_1 and R_2 are selenium rectifiers. C_1 and C_2 are electrolytic capacitors. S is a single pole-single throw toggle switch.

in textbooks[4] dealing with electronic circuits. It is also easy to find material treating the construction and operation of selenium rectifiers and electrolytic capacitor.

[4] See for example, Schultz, Anderson, & Leger, *Experiments in Electronics and Communication Engineering* (Harper & Bros., New York, 1954), p. 338.

TABLE 1

LIST OF COMPONENTS AND SPECIFICATIONS FOR VARIABLE HIGH VOLTAGE DC SUPPLY

2 selenium rectifiers	60 milliamperes with an input rms voltage rating of at least 130 volts
2 electrolytic capacitors	single section—30 microfarads at 250 volts dc working voltage
1 dc voltmeter	0–500 volts at 100 ohms/volt.
1 toggle switch	single pole-single throw
Miscellaneous	hardware hook-up wire line cord and plug material for chassis and panel

MICHIGAN COUNCIL OF TEACHERS OF MATHEMATICS

The Ninth Annual Conference of the Michigan Council of Teachers of Mathematics will be held at the M. E. A. Camp, St. Mary's Lake, Battle Creek, Michigan. on May 2-3-4, 1958. Registration will start at noon on Friday, May 2, and the Conference will close with dinner Sunday noon, May 4. The Theme of the Conference will be "Insights into Modern Mathematics."

In addition to the general sessions, seminar type group meetings will be held, in which topics of "modern" mathematics will be discussed. There will also be discussion groups dealing with classroom problems and planned for elementary school teachers as well as for junior high and senior high school teachers.

The camp is pleasantly located on St. Mary's Lake, four miles north of Battle Creek. Recreational facilities are provided, meals are served in the main dining hall, and dormitory type sleeping accommodations are available for about 150 persons. Hotel accommodations are available in nearby Battle Creek for those who prefer them. The charge for the conference (including all accommodations) is modest, and members of the Michigan Education Association are entitled to a substantial discount. In order to be assured of sleeping accommodations at the camp, reservations should be made in advance. Inquiries and requests for reservations may be addressed to Miss Carolyn Ingham, 500 East William Street, Ann Arbor, Michigan.

POSSIBILITY OF INFECTION MAY RESULT FROM STRESS

New evidence has been found to support the theory that emotional stress increases susceptibility to virus infection.

Three researchers from the University of California at Los Angeles Medical School described such experiments with mice. The virus used was herpes simplex, which causes "cold sores" or "fever blisters" in man. Stressful situations in the mice involved fear of mild electric shocks or several hours of close confinement in a copper screen "bag."

There was a significant increase in susceptibility to infection by the virus in stressed mice as compared to unstressed control mice. This was demonstrated not only in increased death rate but also in a trend toward decreased survival times.

The investigators said they were not certain that the experimental stress was analogous to emotional or psychological stress in man. However, the stresses resulted in behavioral changes usually associated with emotional disturbances in rodents.

UNIFYING IDEAS IN THE ARITHMETIC CURRICULUM*

RICHARD D. CRUMLEY
Iowa State Teachers College, Cedar Falls, Iowa

One of the important contributions of modern curriculum theory has been the determination of the role of ***unifying concepts***. This role has been described in some detail by Tyler.[1] Unifying concepts are those concepts that occur again and again in a variety of situations. For this reason many of them can be used effectively to produce a better curriculum and to bring about better learning. It is my purpose to call attention to a few of these unifying ideas in the area of arithmetic and to indicate how these concepts might be used to advantage.

In order for a concept to qualify as a unifying concept it must be a basic and important concept. If this is the case, the concept is likely to be fairly complex. In the area of social studies, a frequently used unifying concept is the concept that people throughout the world are interdependent. As you can see, it can be stated simply. However, for mature persons, this concept is made up of many associations. We realize that there are many ways in which we are interdependent. We also realize that this interdependency has changed from century to century. In a school curriculum this concept can unify some of the learning in the following way: In the first grade, children are led to realize that the members of a family depend upon each other in many ways. In the second grade, children are led to realize that members of a community are interdependent in many ways. This broadening of the idea of interdependence is extended in later grades to our state, our nation, and our world. The concept of interdependence is not only developed, it also serves to unify or tie together a wealth of information about people in our world.

The use of unifying concepts in arithmetic and mathematics would seem to be quite natural because of the interrelation of the various elements making up this branch of knowledge. Most of us are quite aware of the way that ideas and skills build upon other ideas and skills in arithmetic. What we need to do is to capitalize upon this stair-step arrangement of the concepts in arithmetic.

Let us now examine three concepts which serve well as unifying concepts in arithmetic. These three are not the only unifying concepts that we should use, but they seem to be very important ones.

The first example is the well-known concept that ***our decimal system***

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 29–30, 1957.

[1] Ralph W. Tyler, *Basic Principles of Curriculum and Instruction*. Chicago, Illinois: The University of Chicago Press, 1950. 83 pp.

of symbolizing numbers is based upon grouping by tens. The child first meets this idea in understanding how we write the symbols for the number fourteen. He knows that "1" is a mark for the number one and that "4" is a mark for the number four, but the idea of "14" being a mark for one *ten* and four is a new idea to him. After he has become familiar with numbers expressible by two digits, he meets an extension of the use of tens: whenever we have more than nine tens, we group ten tens together and call this denomination *hundred*. He also learns that we symbolize the number of hundreds by a mark just to the left of the mark for the number of tens.

The child next encounters this concept when he learns that our system of symbolizing numbers enables him to find the result of adding numbers larger than nine by using the addition facts for numbers less than or equal to nine. By using a concrete representation of the numbers such as bundled sticks, he can more easily understand the general procedure for finding the sum of the numbers. The child has seen and used bundled sticks when learning how to symbolize numbers larger than nine, and now he uses bundled sticks to help him learn how to find the sum of numbers larger than nine. The previously learned concept of grouping by tens is the basis for learning to compute the sum of numbers larger than nine. This is the way a unifying concept should work. When the child tries to find the sum of 28 and 36, he works with bundled sticks to discover how to proceed. He forms two groups, one of 28 and one of 36. The group of 28 is arranged into 2 bundles of ten each and 8 loose ones, and the group of 36 is arranged into 3 bundles of ten each and 6 loose ones. Letting the symbol, #, stand for a ten-bundle, we can picture his two groups like this:

```
    #  #  ||||||||
 #  #  #  ||||||
```

The child will then put the loose sticks together, and seeing that there are more than 9 sticks he will make another ten bundle and have 4 loose ones besides. He should recognize that this is fourteen and confirms what he already knows—the sum of 6 and 8 is 14. His sticks now look like this:

```
    #  #
             #  ||||
 #  #  #
```

Without being told, the child will probably know how to finish. He will put the ten from the fourteen with the 2 tens and the 3 tens, making 6 tens all together. He is now in a position to record his work and his thinking in the convenient form:

$$\begin{array}{r} {\scriptstyle 1} \\ 28 \\ \underline{36} \\ 64 \end{array}$$

In this way the concept of grouping by tens helps the child to unify the meaning of the number symbols with the computational procedure for finding a sum.

The child again use his concept of grouping by tens to symbolize a number when he learns about subtracting a number from a number larger than eighteen. Let us consider subtracting 26 from 74. Again his teacher provides him with sticks to help him discover how he can find the remainder without counting. His sticks would look initially like this:

||||

He feels sure that he can take twenty-six of the sticks away because twenty-six is less than seventy-four. How can he do it? One way by which he might do it is to unbundle one of the tens. This changes the grouping of seventy-four from 7 tens and 4 ones to 6 tens and 14 ones. His sticks now look like this:

||||||||||||||

From the fourteen loose ones, he takes six sticks leaving eight loose ones. From the six tens, he takes two tens leaving four tens. The sticks left now look like this:

||||||||

The child will soon be ready to record his work and his thinking in this form:

$$\begin{array}{r} {\scriptstyle 6\ 14} \\ \cancel{7}\cancel{4} \\ \underline{-26} \\ 48 \end{array}$$

Again the concept of grouping by tens is helpful in unifying the meaning of the number symbols and the computational procedure for finding the remainder when subtracting.

The pattern is now fairly obvious. The concept of grouping by tens will form the basis for discovering or for understanding the computational procedures in multiplication. Concrete objects grouped into tens and hundreds will help the child in the case of a one-digit multiplier. Pictures and diagrams are probably better than concrete objects for understanding the computational procedure when the multiplier is a two-digit number or larger. The concept of grouping by

tens will form the basis also for the computational procedures in division, especially if the repeated-subtraction approach is used.[2]

After learning about common fractions, the child extends the concept of grouping by tens when he learns about the decimal system of symbolizing fractions. At this point he should develop a fuller understanding of the entire decimal system. Each place to the left and right of the decimal point refers to a particular denomination. Going from the decimal point to the left the denominations are one, ten, hundred, thousand, etc. Going from the decimal point to the right the denominations are tenth, hundredth, thousandth, etc. Ten of any denomination make the next larger denomination, and dividing any denomination into ten equal parts makes any one of the parts the next smaller denomination. It should be quite apparent how helpful understanding the entire decimal system will be to the child as he learns to add, subtract, multiply, and divide mixed decimal numbers.

The importance of the unifying concept that our decimal system of symbolizing numbers (including fractions) is based upon grouping by tens can be appreciated by the fact that this concept helps all the way from the first grade to at least the sixth or seventh grade.

The second unifying concept that I would like to call attention to is the concept that *in measuring something we use a unit of measure.* At present, this concept is not used very extensively as a unifying concept; however, I believe that it could be very effective. In a school program of instruction in arithmetic, the child deals first with the question, "How many?" Gradually he learns to deal with the question, "How much?" The "how many?" question certainly is appropriate when considering groups of books, or apples, or chairs. These groups are made up of elements each of which has the natural property of being separate. This is not true of the water in a bucket. At least, it is not practical to try to count the molecules of water. We do not consider "how *many* water in the bucket?" Instead we say "how *much* water is in the bucket?" In describing how much water there is, we find it convenient to use a unit of measure, such as quart or gallon. The water can be poured into quart containers and they do have the property of being separate. Now we can change the question of "how much?" into the question, "How many quarts of water were there in the bucket?" You will note that it was necessary to choose a unit of measure before we could describe with some precision the amount of water in the bucket. This is also true when describing amounts of time, distance, area, volume, weight, temperature, and the like.

One reason that the concept, to measure something we use a unit

[2] Henry Van Engen and E. Glenadine Gibb, *General Mental Functions Associated with Division*. Educational Service Studies No. 2. Cedar Falls, Iowa: Iowa State Teachers College, 1956. 181 pp.

of measure, will serve well to unify is that a large number of applications of arithmetic deal with specific quantities of various things. It is necessary, of course, to determine or describe these quantities by using appropriate units of measure. If the child understands the idea of using units of measure, he will be able to see some common aspects of a large number of these applications. Furthermore, we can assist him in learning the important reason why arithmetic can be used in so many situations—namely, that numbers may be used in connection with any unit of measure. An example is the fact that four of any unit of measure when combined with five of the same unit always make nine of that unit. It make no difference whether this unit is a foot, a pound, a mile, a gallon, or a dollar, the result is always nine units.

Another way in which the concept of using units of measure can unify is with regard to fractions. Many times, to measure something rather precisely we need a unit of measure smaller than any of the standard units available. For example, we may want a unit of measure smaller than an inch. To get a smaller unit, we may divide the inch into four equal parts and take one of them as a new unit called fourth-inch. We may do this with any unit, so we abstract the common idea of all fourth-units and obtain the new number called one-fourth. Three-fourths is understood then to be three of the smaller measure, fourth-unit. The use of the unifying concept about units of measure ought to help the child understand fractions and their use better than the present emphasis on cutting up pies.

Let us now consider a third unifying concept—the concept of *rate*. Rate is taken to be a generalized ratio. In non-rigorous terms, a rate is a correspondence of so much of something to so much of something else. An example of a rate-situation is the way that eggs are sold. The correspondence is that for each dozen eggs brought, we pay fifty-two cents. For two dozen eggs, we would pay one-hundred-four cents *at this rate*. The sale of three pounds of hamburger for one dollar is another rate-situation. In fact anything we buy is sold at a certain rate. Wages and salaries are rates, also. Per cent is a rate, the distinction being that the rate is always so much per hundred, as the original Latin phrase *per centum* would be translated. The concept of rate seems to be in most problem-situations that lead to multiplication or division of whole numbers or mixed numbers. This leads me to believe that the concept of rate can be very effective as a unifying concept. Space does not permit a more detailed consideration of how this unifying concept might be used.

It is hoped that the three unifying concepts mentioned have illustrated how useful and important such concepts are. Good textbooks are organized in such a way as to take advantage of some unifying

concepts, and textbooks will be better when more unifying concepts are used. Teachers, of course, are in a position to help the child unify his learning by calling attention to the ways in which the various concepts and skills of arithmetic are related. Teachers can often be more effective in doing this than textbooks. After we become aware of the great worth of the use of unifying concepts, we ought to make every effort to understand them and their use. A greatly improved arithmetic curriculum is sufficient reward for our efforts.

MILLIONTH-OF-AN-INCH FILM MADE FROM ALUMINUM "RUST"

Films of aluminum rust only one-millionth of an inch thick are being used by Westinghouse Electric Corporation scientists to support sensitive materials inside experimental electronic tubes.

The films, which are so thin they are almost perfectly transparent, are prepared from ordinary aluminum foil such as most housewives use in their kitchens. Westinghouse scientists dissolve the aluminum, 99.9% of the foil, in an acid and use only the very thin film of aluminum oxide, or "rust," which remains undissolved.

Ultra-thin discs of aluminum oxide over two inches in diameter are now prepared routinely.

Because of their extreme thinness the films do not interrupt the path of electrons directed at the sensitive materials they support in experimental imaging tubes.

RADIOACTIVE GAS TRACER AIDS "SHUNT" DETECTION

A radioactive gas tracer which can detect blood leakage, or holes between the heart chambers, has been demonstrated. Dr. Robert B. Case and his associates at St. Luke's Hospital used ethyl iodide tagged with radioactive iodine which the patient inhaled.

The patient breathes the gas for 15 seconds after which it is absorbed by the blood and travels to the left side of the heart. If there is a hole between the chambers of the heart, a quantity of the tracer blood shunts across to the right side of the heart where samples are rapidly drawn off.

This tagged blood, from the right chamber, is then compared with blood taken simultaneously from a leg artery. The amount of radioactive tracer found in the blood from the right chamber determines the amount of leakage, i.e., the size of the defect.

Shunts, the physician's name for leakages within the heart, had previously been detected by having the patient breathe a mixture of the gas nitrous oxide and tracing its course through the circulatory system.

Another method employs a harmless blue dye injection into the blood stream while the standard method is to introduce a thin tube through an arm vein into the right heart chambers and draw off blood samples directly.

The advantage of the radioactive tracer lies in the fact that the size as well as the defect itself can be determined before surgery by comparing the count of the two blood samples.

The methods previously used were hit and miss or, if the defect was detected, unable to determine the size.

"WHAT'S NEW"*

A. W. Carlson
E. H. Sheldon Equipt. Co., Muskegon, Mich.

I am not going to be another to tell you what is wrong with our present Science Programs in schools, because I find we are being told by experts.

As equipment suppliers, we have been aware of this problem for a long time, and since it affects our business, we have decided to put some effort into finding solutions from our end. We believe that our background for this is a good one. Since we are in the equipping of so many high school and college laboratories, as well as the modern industrial laboratories of Alcoa, Goodrich, Eli Lilly, Armour, Continental Can and Glidden, to name a few, we find that we have someting to contribute to the solving of these problems.

We are particularly aware of the inadequacy of present facilities. The teacher's task has become more arduous. Student interest and participation has fallen off, and where this is so, we believe a modern appearing, well planned laboratory can help greatly. It can help the teacher by solving his storage problem by saving him steps and time, by having materials at the place of use for the students and for demonstration purposes. It can save him many steps during the day through well planned traffic patterns and work areas more compactly located. It can help the student interest and work by providing well planned work surfaces, student storage, safe and efficient ways to get about the room, as well as providing an up to date, attractive laboratory, which will attract his interest. If we can supply this efficient environment, helping the teacher, and the student, then we believe we are helping the community, as well as the nation.

We still face obstacles of a static inertia of traditional thinking, old fashioned teachers, textbooks which are not up to date, administrators who do not see the advantages of modern planning in their science department, and, of course, the lack of money.

The ordinary approach to solving the design of the laboratory is the usual one of having the laboratory plan of a college from which the teacher came, or the usual old stand-by cliché room plan and table design. There is always a reluctance to part with old designs, and so, we, like so many others, took to pushing the old tables about the room trying to come up with a good solution. This resulted in the perimeter planning with which we are all so familiar.

Just re-arranging the same old tables in the same old room didn't

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 29–30, 1957.

solve the problems of traffic and storage and appearance, nor did it take care of the many special projects that should take place within the laboratory. By a study of what should go on in high school science, which includes methods of teaching, study of student and teacher storage requirements, and some idea of where the future leads, and working with you educators regarding these problems, and after much prodding by you, we were able to design laboratories which were different . . . laboratories which looked different, which were functional and Educationally Correct.

We recognized that problems of inadequate room facilities, equipment and supplies, and classes which are too large are bound to affect the student control, and make for student traffic friction. There is student friction at their individual work stations and always the problem of transportation of equipment and supplies within the room.

A poor laboratory layout makes for difficult teacher circulation and access to work stations and other parts of the room, and, of course, difficult schedules involving several preparation set-ups affects the teacher's efficiency. Add this to the new science curricula which requires experiences that develop knowledge, understanding and appreciation of the important principles of science, experiences that apply an understanding of the contributions of science to daily life, that integrate facts and concepts and principles from the several science fields, experiences that provide practice in applying important scientific principles under laboratory conditions, and require the manipulation of scientific equipment and measurement with scientific instruments. The new curricula must have experiences that provide opportunity for students to design and construct technical or semitechnical apparatus, that develop an understanding of the elements of the scientific methods, experiences in reading and interpreting the various types of scientific publications, in performing inductive and deductive laboratory experiments, and those experiences that encourage the development of a variety of scientific interests. Just as important are those experiences that provide an opportunity to study problems involving science in the home and in the local community, experiences that develop an understanding of the place of science in the conservation of natural and human resources, some that emphasize recent science developments and those that aid students in developing desirable scientific attitudes. . . . You MUST have a laboratory that provides facilities for these new directions for science education.

There must be areas where lecture and visual aids may take place, and, of course, a laboratory work space for the workbook problems, a place for reading and research. There must be display areas, and

certainly an area set aside for special projects. There must be room for individual and group activities, and the room must be so arranged as to show the relatedness of one science to another. There must be flexibility in procedure. Storage, of course, must be specific, but it must also be distributed. Services must be located centrally, as well as ready for use by the individual. The ease of student and teacher traffic throughout the room must be considered. For good supervision, the teacher may spend much of his time at a central location, but should have immediate straight-line access to all parts of the room, with all parts of the room open to view. All areas must be multipurpose in use, so as to take care of fluctuating enrollment and needs of the teacher in scheduling and possible changes in curriculum. Obviously this laboratory should have all the facilities self-contained so as to eliminate the problems of shared rooms. All elements for safety of students and equipment must not be overlooked. The word Economy enters here, also, with considerations as to the first cost as compared to saving the teachers and students time during an all-too-short day.

I am not telling you anything new when I say that the student learns through reading of textbooks, reference books, science magazines, newspapers, industrial pamphlets, workbooks, science biographies, and current science literature. He also learns through the display, pictures, collections, mock-ups, bulletin boards, charts, specimens, aquaria, living plants and animals, posters, etc. He learns through class discussion, panels, small group discussions, formal and informal discussions. He also learns through experimenting with individual experiments, student and teacher demonstrations, observation of phenomena and testing of techniques. The student learns through conferring, student committees, co-operative projects, interviewing, the pooling of data, working together, etc. The student learns through visualizing. There are film strips, slides, photographs, museum visits, models, telecasts, micro-projections, displays, mock-ups, etc. The student learns through studying, organizing ideas, by writing papers and reports, self testing, arranging and interpreting data, relating science to other courses, explaining science concepts to others, making applications of science to related problems. He learns through listening to tape recordings, records, teacher explanations, radio, outside speakers, and student reports. He learns, of course, through creating, the development of projects, devising new experiments or methods of experimenting, carrying on junior research, applying science principles to the daily problems of living. The student learns through providing guidance, making suggestions, planning a wide variety of learning activities, working with individuals, evaluating of student achievement, providing source materials,

stimulating student activities. He also learns through the related school activities, of science clubs, science assembly programs, museum and nature trails, planetariums, observatories, nature camps, field trips and industrial trips. We must take care of the students at all levels of ability, and the teacher must be allowed to reach out to all these levels, according to the foregoing. . . this will have to be SOME laboratory.

It will have to take care of all experiences, the whole child, a total of experiences. Let's call it a "Total Experience Laboratory." Let's use this term to designate the facilities for varied activities and use this term to designate the varied group sizes, with emphasis on the relationship between the special sciences and in relationships to life experiences, whether it is for living, work, or for college preparation.

I would like to show you the physical requirements for such a laboratory, and why it may be called a Total Experience Laboratory. These new plans and equipment are offered by us, and six other suppliers, and do not make up an expensive laboratory when everything is considered. We pioneered in the search for good science laboratories, and have used prominent educators for four years as advisors for science, as well as other educational leaders in Homemaking, Art and Industrial Arts, so we feel this story is your story.

Let us visualize a room, 22 to 24 feet wide, by 56 to 64 feet in length. At one point in this room, let us set up 24 to 32 tablet armchairs for discussion, write-ups, and study area, within easy view of an instructor's demonstration table and a nearby chalkboard. Within the immediate area of the demonstration table, there will be storage shelving and cabinets which will accommodate the most often used demonstration materials, and apparatus. These can be stored under the demonstration table, behind the sliding chalkboard panels, in shelves and cupboards below the chalkboard, as well as the cupboards at either side. This will eliminate many a long walk to the end of the laboratory into the old stockroom to hunt for demonstration set-ups. A screen can be hung above the chalkboard, and a projector stand set up at the rear of the lecture chairs to complete this grouping. It is with this grouping that we educate the student's head.

In order to give this student an arm to go with his educated head, we group student work tables adjacent to this lecture area. The tables are adequate in size, but not wasteful of top area and therefore, floor area, but they do contain all of the necessary services and adequate storage below to do the job of providing the space for individual or group use. The design of the table is such that there is additional work surface available adjacent to the rear, where notebooks may be kept, or balances set up. The tables, when placed diagonally to the walls of the room, provide for easy traffic from one

student position to another within this area without interfering with students at work. There would be few stools necessary in this area, since the lecture chair area is so close by. The over-all area occupied by student tables is compact by virtue of having the tables placed diagonally in the room, based on the same idea as many crowded resturants use to conserve space and still provide ready access to the tables.

If a fume hood is located adjacent to the student table area, and is designed so that a group of students can gather about the hood in order to see the reactions taking place, this hood then becomes a really useful area for close demonstration, and may be used by the teacher for general demonstration to larger groups. This hood, located properly, can also become a preparation area, and may be the storage point for bulk chemicals. Individual students may use this hood for their special projects. Nearby may be located closed storage cabinets for general and reserve supplies. A movable supply cart is a handy thing to have in this area.

Our student, with his educated head and one hand, now may receive another arm. In the form of a semi-enclosed area in which Light experiments, work with optical instruments, may be carried on, as well as biological studies, such as the effect of light on plant life, together with legitimate photographic darkroom activities, all can be contained within this area, if a lightproof enclosure, such as a sliding or folding, or a fabric door is provided. This area is then open to view, except when used for photographic work. Activities of a chemical nature may be confined to this entire end of the room.

At the far side of this room, however, away from chemical contamination, we might set up another special projects area, taking care of the physical aspects of science, where work in electronics, mechanics, communications, wood, metal, plastics or fibers may take place, away from the corrosive chemicals found near the student tables. On benches in this part of the room, work in maintenance and repair may take place, using the vise which may be mounted on the bench top. In this area, too, let us finish out our student education with areas set up for displays, where student work may be shown, related sciences brought into the picture, models may be set up, and other three dimensional material, industrial processes may be diagrammed, as well as the current study projects in process. It is here where the student may refer back to the previous demonstration conducted, as a basis for his present day assignment, to refresh his memory, to seat more firmly in his mind the relationships with that which has gone before.

Let us clothe our educated student with a reading and reference area where one or more students may get away from the crowd in

conference, project planning, for the reading of current publications and news articles that would otherwise never appear in the main library elsewhere in the school. Scatter about this room storage cabinets of various types, wherever there may be space, and I believe we have described a typical Total Experience Laboratory.

In this plan, we have provided facilities for reading, displaying, discussing, experimenting, conferring, visualizing, studing, listening, creating, guidance, and have provided space for individual and group activities. We have provided for flexibility of procedures, we have provided separate functional activity areas. We have taken care of the distributive storage and specific storage. We have taken care of all traffic problems, and have eased the problem of supervision. Here we have given the gifted student a place to work.

* * *

I have just led you through the planning of a Senior High laboratory and now I would like to show you some new thinking at the Junior High general science level.

Obviously, the future of our science is imperilled unless we provide the greatest opportunity for youngsters to have an early interest in science careers. Educators agree that the shortage of college science graduates has its beginning at the Junior High level. Today, all science is life science really, so closely do the related sciences of Chemistry and Physics control our food, clothing, shelter, transportation and communication, as well as our health, safety, and freedom for the pursuit of happiness.

This Junior High laboratory, as a result, is called the Life Experience Laboratory. Science textbooks are of no less importance, but the Salk vaccine was discovered, and polio practically eliminated before the story had time to appear in textbooks. Even science textbooks are history books, but fall short of providing the latest learning and living experience with the latest living world of science. In this late science, teachers and pupils live and learn together.

With working area and apparatus at hand, we may lift science study out of the textbook routine and into the absorbing channels of Experiment and Project. It is this "learn by doing," rather than by reading and writing, that can make science so much more interesting. Instead of driving action minded students away from science, as so many textbook courses do, this type of planning invites them to participate in it. Every corner of the science room will have its store of raw materials, tools, models, collections, instruments and literature provided for in proper order and accessible. This, in addition to the work top space, for both teacher and pupils to use and to organize these essentials, provide for real classroom experiences.

These areas can develop according to traditional subject matter

units; their order and grouping make transition from one to another easy and natural. Storage facilities should accept and keep as much of the material visible as possible for instant indications and recognition of the relationships between the sciences. This makes possible easy fluid transition from one area of science to the other, with the greatest flexibility, with the maximum of efficiency in the modern living science classroom. Each area is a demonstration center with its specific services and facilities, with all storage at fingertips or at the point of use, with much of the demonstration material permanently mounted or self storing. With a place for everything, and everything in its place, this might be called a "fitted" laboratory, much like a "fitted" traveling bag.

One or one and a half classroom size General Science laboratory will take in addition to the usual pegboard, chalkboard and tackboard surfaces, cork faced panels which are pivoted, and turn around, and panels which tilt down. On these panels are mounted the display apparatus, charts and diagrams, instruments and three dimensional models easily revealed to the pupils or pivoted about and locked when not used. The face of these pivoted panels may be covered with tackboard so that diagrams and charts and items of general interest may be tacked up, practically anywhere in the room. The tables in this Junior High laboratory would be semiportable with some storage in the tables, and the tables so designed that they can be used anywhere in the room, in formal rows, or pushed against counters or islands with sinks in them when water, gas or electricity is to be used on the tables. Any one or more of the tables may be used as a demonstration table by a teacher or pupil designated for that job.

A typical setup might consist of tablet armchairs and adjacent tables set up around a demonstration display of a Light unit; many references back to what had been learned about Heat during previous sessions may be easily made, since the two unit display could be adjacent. This same relatedness can be demonstrated with these display setups of units of Light and Electricity, Electricity and Sound, Heat and Chemistry, Chemistry and Life of plants and animals, the effect of Light and Heat on Life . . . all of these relationships can be readily demonstrated in a room set up this way to carry the student through the entire gamut of Life Science. This then becomes an activating, interesting life experience laboratory and gets the student out of the category of read, write, and recite, into the physical contact with instrumentation, models and displays.

This type of room, then, with flexible arrangement of student tables and tablet armchairs and instantly available demonstration material in all parts of the room, presents a challange to the Junior High Science teacher for capturing our young people for Science.

SUPER CHARGERS FOR ELEMENTARY SCHOOL SCIENCE VOCABULARY

PEARL ASTRID NELSON
School of Education, Boston University, Boston, Massachusetts

Words charged with meaning.—Psychologists and educators in general have accepted the idea that some words are more highly "charged" than others. Public speakers have purposely injected these highly significant words into their lectures for the purpose of obtaining the attention of the audience, especially during the occasion of a dull or overly long speech. These electric words or phrases may have to do with sex, politics, religion, race or country, yet they are immediate attention-getters and the sleepiest audience in the world will respond to interjections of words of this type. We must use attention-getters in education. In science especially are we anxious to know methods of charging words with significance and meaning. It is possible that many scientific concepts and understandings hitherto not considered suitable for children of elementary school, may become fitting, necessary and pertinent if they are charged with drama, excitement and pertinence before they are used as part of the commonplace vocabulary in the classroom.

Where do we start?—There has been acceptance by teachers and publishers of textbooks alike of the fact that there is a definite need for more physical science teaching in the elementary school of today. Indeed, we may be accused of giving a "sling-shot" education in a hydrogen-bomb age. Although this may not be true in all communities, there is a felt need for more teaching of the physical sciences in the elementary school than ever before. The reasons are all about us and very obvious. We have probably overdone "opportune," "accidental" and "incidental" science teaching at the lower level. We still may build on the interests of the child, and certainly we believe strongly in an intergrated curriculum, but perhaps we have been too willing to wait for the knock of science on the door of the classroom, for Billy to bring in his steam engine before we study the forms of matter, or, in some cases, even for a thunderstorm before we are able to study erosion. There are those general practitioners in education who have "set the stage" if the rains did not come or if Billy failed to bring in his engine. To them certainly be honor and glory! To the question, *where do we start*, then, let us say . . . *in the classroom!* At what grade level? Try it at the level at which you are teaching now!

Think of a word.—This is reminiscent of the old arithmetic quizz which always started with, "Think of a number, add ten, etc." This time we are going to think of a science word, and then we are going

to add other science words, all of which have some connections or relationships with the others.

Try these for size.—Matter. We would like to get across to the pupils in a third grade that matter is something which takes up space and has weight. Find a colored picture of a girl and a boy fishing: There is water, sky, a frog sitting on a lily pad, a bird in the tree. (Choose your own picture: this one is not arbitrary.) Now have models of the things in the picture to supplement your teaching of the word ***matter***. A frog model represents solids, and the pond certainly represents liquids. To teach the fact that a liquid always takes the shape of the container it is poured into, by all means have a Pyrex-plate and pint-sized and quart-sized milk bottles handy. A balloon will be necessary to teach that air, a gas, takes up space and has weight. Since the liquid, water, is available, try teaching surface tension also. Children enjoy placing paper clips in a dish already "filled" with water, and watching a lens appear. Hundreds of clips may be slipped into the dish before the surface tension is disturbed and the water spills over the edges.

Changes of state.—Gases can become liquids or solids; liquids can become gases or solids; solids can become liquids or gases. These are called *changes of state*. "Evaporation" may not be forever a verbalism if the children understand that ether, alcohol and gasoline evaporate faster than water. With a cloth, place a spot of alcohol on the chalk board; beside it, place a water spot. Watch the rate of evaporation. Try this also with ether and gasoline. The odor of these liquids alone will charge these words heavily, and the understanding that evaporation is the change of a liquid or solid to a gas will be taught through the sense of smell. Even very small children understand the word *melting*. It is wise, however, to review the meaning by burning a candle, and allowing the paraffin odor to permeate the classroom. *Dissolving* is different from melting.

Not all solids will dissolve in water. Pour a solution of copper sulphate into a funnel lined with filter paper. The water which drips from the funnel will still be bright blue. Now try water in which sand has been placed and stirred. The sand will remain in the filter paper, and the water color will not be changed. Try sugar dissolved in hot water and taste the resulting product, try salt.

Can you think of others?—How about the words *freezing* and *condensation?* How can you charge them with science meaning? Science words are limitless, and certainly if they are charged with meaning and concomitant understanding there can be no particular grade placement for them. For bigger and better science in the elementary school let us start with ***the true understanding of words!*** Let us charge these words so positively with meaning that science education will go

on and on and there will be no terminal learning.

Dare to try some difficult ones.—Perhaps chemistry bothered you in high school and you are very willing to go along with the timid souls who say that chemistry does not belong in the elementary school. Dare to be different, and try to explain by this potent method some of the words which may still be verbalisms to you. Let's try the word *element.* Chemists tell us that there are more than ninety simple substances out of which matter is made. We know that today, and especially during the International Geophysical Year, the list of ninety is spilling over because of mans' constant search for new elements for use in this scientific age. If we round the figure to one hundred, the pupils will probably remember the number more readily.

Make a collection of these elements. You will find it comparatively easy to obtain aluminum, gold, tin, nickel, mercury and copper, but more difficult to exhibit lithium, antimony, strontium and nitrogen. *Why* are these last named elements more difficult to show? Are there any ways that we can obtain them? What are these hard-to-get elements, and for what are they used? How can we find out? (Let's not depend upon our friend, the high school teacher, for a quick loan. He, took is usually short and living on a limited budget!)

Pin-ups and hero worship.—Pin-ups need not be discouraged; substitution of the idol may be the answer. Curium, a new element, was named for the famous Curies, the discovers of radium. What other people led daring and dangerous lives to perfect a theory or to delve into an unknown field?

Compounds and mixtures.—While we may place a fairly accurate figure on the number of elements in the world it is not possible to do so with compounds and mixtures. Take alloys. Alloys are mixtures of metal. Is it possible to collect samples of these alloys and to discover their uses? Bronze, a mixture of copper and tin, and brass, a mixture of copper and zinc are very common and easily obtainable. Where are the mines, the foundries, the factories? Yes, this is social studies; it is research in the scientific method; . . . it is problem solving; it is learning!

Need some starters? There is no particular starting or stopping place as far as science words are concerned. You can start in a specific area and limit the words to those concerned with or relative to that particular field, or you may decide to use vocabulary as a starting off place for a certain project planned for the future for which a definite reading, writing and speaking vocabulary is necessary. What can you do about the following list of words? How can you charge them with meaning and understanding?

molecule	solvent	diffusion	alchemy	atom	bases	acids
catalyst	electric	carbon	bacteria	formula	cohesion	

ONE ANSWER

WILLIS SWALES, JR.
Hillside High School, Hillside, New Jersey

On Thursday evening, November 14, 1957, the President of the United States set forth some thoughts that immediately started a revolution in education. In essence he said that our scientific and mathematics programs within our schools need to be redesigned, re-evaluated, and re-tooled to our present day critical world situation.

The President was indeed correct. But, he is a few years late. The science and mathematics teachers of our nation have known for many years that our output of scientists has been falling far short of what was actually needed. We have known, but, what have we done? The answer is simple, "Nothing."

It is fortunate that we are not too late. The Russian scientists have been producing great things in Sputnick I & II, huge airplanes, and a "mass produced" educative system. The truth is that what they have been producing so far has been coming not from their own educative system but *chiefly* from the educative and vast scientific pool of Adolph Hitler. A great number of their scientists are Germans they captured during the 2nd World War. I must emphasize the fact that they are now getting help from the German scientists—tomorrow they may be exclusively on their own.

But what of our own problem. The problem of interesting, encouraging, and teaching our own young people to be our own scientists. I am sure that what I have to say here is not entirely new. I am sure that what I am suggesting is at present being tried somewhere in our great nation. I am also sure that this is not the only answer. Anyone who can supply something more workable owes it to the nation to set it down and tell all of us about it and how it worked for him.

The scientific education of our future scientist needs to begin back when he is most susceptible to learning. The science teachers that we have in our grade schools are on the whole unprepared in science. To offset this I suggest that large enough school systems have a science teacher that will teach nothing but science or science and mathematics in their grade school. This must be a teacher that has been trained and can answer the inquisitive youngsters' questions *scientifically*.

The 4th grade is not too early to foster this interest in science in the schools. That is perhaps the level that the youngster is becoming the most inquisitive into the real why of things. Here he is beginning to lose the last vestiges of his childhood and starts to think of himself as a man. At this age he can think deductively and even analytically about many things—so certainly about science and scientific facts. With a good, thorough, understanding, and knowledgeable teacher

the youngster can set the base to become the future scientist. A science teacher in the 4th thru 6th grade is as important as the physics and chemistry teacher in the high school. If the foundation is laid in the grade school the high school teacher can teach.

It is at this early age, probably at the end of the youngster's 6th year, that a science aptitude test would be given. As the youngster moves from the grade school into junior high he could then be encouraged and advised whether or not to go on in science and math. This would mean putting a scientific course into the curriculum, not just an occasional course but a definite pattern. Educators have known for a long time that we are not pushing the majority of our youngsters to capacity. The scientific course would give this push. This could be the pattern.

	Science	Math
7th year	General Science—Physical	Algebra I
8th year	General Science—Chemical	Algebra II
9th year	Biology	Plane Geometry
10th year	Chemistry	Solid & Trig
11th year	Physics	Calculus I (Differential)
12th year	Advanced Physics or Advanced Chemistry—depending upon demonstrated aptitude	Calculus II (Integral)

Here is where I would like to indicate what would make this advanced scientific course work. I would also like to emphasize that this program would not work in all communities. This would work best in the communities that have engineer requiring industries, or even a single industry. I will talk later of the answer for other communities.

Immediately following the President's speech many industries, state boards of education, school districts and individuals asked "What can we do?" And, as I have said before, here is where our program can work. The key to open the door—and to keep it open—is industry and the school and the teacher. Each would use the others. I would like to think, since I am a teacher, that the teacher is the most important key. As I explain though, it can be seen that without industry and its wholehearted cooperation and support the program would fall flat. In my own community, industries such as Bristol-Meyers, Westinghouse, Cooper Alloy, Heil-Body, and their laboratories and engineers would be as important as the teacher and the school.

It is in this industrial help that my plan evolves from something that is not uncommon into a radical answer that would add interest in a science career. Simply, it is this: The young students taking chemistry in the 10th grade, physics in the 11th grade and advanced work in their senior year would be out of school 2 hours earlier than the other students. I might say here that 2 hours would be a minimum, 3 hours would be more satisfactory.

The science students would be using the out of school hours to work in industry with a carefully selected engineer or scientist in one of the participating industrial firms. Motivation by working with the scientist would be tremendous. Several ***students*** could be assigned to an individual. They would follow this procedure four days a week and the 5th day one of the participating scientists would hold a seminar on a phase of his particular specialty. Special lectures by other agencies could also work in here. With the training given by the working scientist, the student could get invaluable knowledge that many sessions over a text book would not give.

The summer time of these embryo scientists is also important. The participating industries would hire these students as laboratory assistants at a normal wage. Here they would again be subjected to the "scent" of science, and, more important, exposed to the analytical workings of a carefully trained scientist. Any small amount of knowledge that they pick up would be another building block in the scientist foundation. The student lab assistant would work for 5 hours in the laboratory and have 2 hours of lecture work in the high school each day. A 6 week summer program of this would be ample.

If a student shows a particular aptitude while working in this program, the participating industry could conceivably send the student to school. The industry could protect it's investment by a contract with the student for so many years' work following graduation from the college or university.

The high school science teacher would be a most important participant in the program. He would keep careful records of progress, aptitude, interest, and over-all suitability to be a scientist. He would need to be retained in the summer program to coordinate all of the activities of the program, teach special subjects, and advise the industry trainer on special student problems.

I have mentioned before that all communities could not participate in this program. The answer for these communities is a "county school of science." The problem of getting scientists is certainly real enough to place it on a step equal to vocational and agricultural problems. There are many counties in the rural areas that have these special schools. The "school of science" could become a special part of this school.

In some school districts the high schools are on double sessions. This program would be particularly adaptable to such a situation since half of the students go in the morning and half in the afternoon.

This program has advantages. First and most important is the creating of an interest in science which has been so lacking in our nation. Secondly it would keep us safe from aggression by giving us scientists that would work on weapons if necessary, to deter aggression.

In summary, I must say that there are many weaknesses in this program. But there is no known program that does not have weaknesses. This is not the time for us to sit and say "That program won't work because it would mean changing too many schedules," or "Industry won't cooperate," etc.: If we wait, history might say "It would have worked, but now it is too late."

REACTIONS TO "CALCULUS: A TRIGONOMETRIC PROCEDURE"

GEORGE G. MALLINSON, *Editor*

In the January 1958 issue of SCHOOL SCIENCE AND MATHEMATICS there appeared an article entitled, "Calculus: A Trigonometric Procedure" by John J. Aeberly. The article was reviewed critically by Professor Cecil B. Read, Mathematics Editor, and then returned to Mr. Aeberly. Mr. Aeberly defended the presentation and hence it was published at the judgment of the editor.

Since that time several strong reactions have been received. Mr. Aeberly responded with the following comments:

"The article entitled, "Calculus: A Trigonometric Procedure," was written at the request of the Committee. Before it was written, it was under discussion with a number of the men interested in the work of the Committee, among them an educator, two outstanding structural engineers, and two architectural designers. All these men are well-trained in mathematics. They have not only maintained their proficiency in mathematics because of daily necessity, but three of them have had such a deep interest in the subject that they have developed it as a hobby. One of these has been a subscriber to your JOURNAL for several years. I tell you all this so that when I briefly outline their conclusions in connection with this article, you may have every confidence that their opinions must be recognized.

This article was thoroughly analyzed in respect to the many unusual developments of the basic principles in pure mathematics that it contains. It has been accepted by these men and their associates on the Committee as correct, and they have adopted it as the basic article, containing the elements in pure mathematics necessary to properly process any equation known to man. They have taken the position that a constructive criticism of this work, which they refer to as the "Aeberly method," must begin with a mutual agreement that the increment Δx shall be clearly and explicitly defined.

The basic definition of the increment, as used in this method, appears in the article on page 47, beginning with the third paragraph and ending near the bottom of the page. This definition of the increment is consistent with the concepts and rules of procedure fundamental to the requirements of pure mathematics. If any individual or group of mathematicians is willing to present an alternate definition, which will be as easily comprehended by the student and the instructor as the one contained in this article, a careful study will be made of it. If it proves to be a better one, the Committee will be prompt to acknowledge its merits."

It was agreed to publish a historical note about the "Aeberly Method" as well as one of the reactions to the article. Further reactions should be sent directly to Mr. Aeberly.

AUTHOR'S COMMENTS ON "CALCULUS: A TRIGONOMETRIC PROCEDURE"

JOHN J. AEBERLY
Chief of Bureau of Heating, Ventilation and Industrial Sanitation, City of Chicago

In the January issue of this JOURNAL there appeared, on pages 44 to 52, the article entitled, "Calculus: A Trigonometric Procedure" by John J. Aeberly. This article was submitted for publication by the Chicago Committee for the Simplification of Mathematics.

The author had been engaged in the simplification of other scientific procedures when, in 1948, he perceived the need for simplification of higher mathematics in many of its aspects. After a period of intensive research, he published a monograph in the spring of 1952 entitled, *The Reorientation of Infinite and Zero Values in Differential and Integral Calculus*. Subsequently he published additional monographs, among them *A New and Simplified Approach to Calculus* in 1954. This latter publication contained a "challenge" concerning the accuracy of three distinct concepts in calculus and offered an alternative to each of these concepts.

A few years ago the press throughout the country began to publish articles in which prominent educators presented critical views of the science and mathematics programs in the schools. Most of these articles emphasized lack of student interest, obsolete teaching methods, and the failure of the curriculum to require an adequate number of hours devoted to science and mathematics. Only a few directed attention to the need for simplification of the subject matter. Consequently a group of civic minded men engaged in the building and construction industry in the Chicago area decided to form the Chicago Committee for the Simplification of Mathematics. Their objective was a simplification of the subject matter of the field of mathematics as a contribution to the urgent national problem of training an adequate number of scientists for the future.

This Committee was planned as a comprehensive organization which would include the leading associations of the building and construction industry as well as other interested groups in the Chicago area. The groups presently forming the nucleus of this organization are the Chicago Association of Consulting Engineers, the Chicago Chapter of the American Institute of Architects, the Ventilating and Air Conditioning Contractors Association of Chicago, the Builders Association of Chicago, and the Building Construction Employers' Association. Each of these associations appointed a sub-committee of three of their members to serve on the Chicago Committee for the Simplification of Mathematics. The chairman of each sub-committee

is a member of the Council of the Chicago Committee.

These engineers, architects, and contractors decided to make a study of the new approach to calculus contained in the monographs published by Mr. Aeberly. After a review was made of these publications, the Chicago Committee concurred in his recommendations. His work was then submitted to a special technical advisory group. This group concluded that the author's new ideas were sound and should have general acceptance. The author had advocated the use of trigonometry as a suitable basis for the simplification of calculus and had indicated that the adoption of this idea would result in an analytical procedure based upon arithmetical progressions rather than upon the more complex geometrical progressions presently used. He had also suggested changes in the graphical presentation of analytical values.

The Chicago Committee then requested the author to present some of the basic principles of the "Aeberly method" in an article to be published under the title, "Calculus: A Trigonometric Procedure." The views contained in this article are a marked deviation from a number of the conventional procedures and concepts in differential and integral calculus.

The basic concept which the Committee suggests for careful analysis is the author's development on page 47 of the January issue of this JOURNAL where the increment is explicitly defined and compared with the indefinite, symbolic increments used in present conventional methods. Since this concept is the basis of the "Aeberly method," it is the recommendation of the Chicago Committee for the Simplification of Mathematics that those who question the content of this article should approach the problem from the same premise as that of the author, namely, the need for a non-symbolic increment which is simple and explicit and which remains finite to the limiting position.

The primary objective of the Chicago Committee is to obtain the general acceptance by educators and other competent authorities of this new and simplified approach to calculus which has as its basis a trigonometric procedure. The Committee is convinced that the adoption of these changes will provide the impetus necessary to renew student interest and will remove one of the most difficult obstacles to the study of higher mathematics.

A REPLY TO "CALCULUS: A TRIGONOMETRIC PROCEDURE"

CHARLES D. KUGLIN AND RICHARD E. STEARNS
Carleton College, Northfield, Minnesota

In the January 1958 issue of this magazine, there appeared an arti-

cle by John J. Aeberly entitled "Calculus: A Trigonometric Procedure." The stated purpose of the article was "to recommend a basic approach to calculus wherein all symbols and procedures are clearly defined and the use of these is kept consistent with our basic principles in mathematics."[1] This new approach, made necessary because calculus uses symbols in "violation of many of the fundamental rules of mathematics,"[2] was presented as "a continuation of our basic understanding in all branches of mathematics, and not as something new and apart from the four fundamental processes and the proper use of the equality sign."[3] Although no one can deny the value of new approaches to existing theories, and attempts to put more rigor into mathematics are certainly worthwhile; it is our opinion that there are two ways in which this paper was not entirely satisfactory. First of all, we feel that some of the statements about calculus are misleading, others incorrect; so that the article does not do justice to the modern treatment of the subject. Secondly, it is our opinion that the new approach to calculus offered must be developed more completely before it can be considered as sound theory. Regarding the first point, we should like to examine the limit concept of calculus and the definitions of the increment and differential in order to point out several instances in which they have been incorrectly used.

Consider the standard definition of a limit:

(1) $\lim_{x\to a} F(x)=A$ if and only if for every number $\epsilon>0$, there is a δ such that if $0<|x-a|<\delta$, then $|F(x)-A|<\epsilon$ when a, A, ϵ and δ are all real numbers.

(2) $\lim_{x\to\infty} F(x)=A$ if and only if for every ϵ, there is an N such that if $x>N$, then $|F(x)-A|<\epsilon$. This second definition is made because ∞ is not a real number.

Notice that the conditions of definition (1) do not say that $F(a)=A$ or even that $F(a)$ exists, because $|x-a|$ is not greater than zero when $x=a$. The following equation which appears on page 50 is an incorrect usage of the limit concept:

$$e=\lim_{(x_1-x)\to h\to 0}[1+(x_1-x)]^{1/x_1-x}=(1+h)^{1/h}=(1+0)^{1/0}=1^{\infty}.$$

The discussion of this says: "no known method in mathematics will prevent the absolute value of zero from entering the equation if (x_1) is made equal to (x)."[4] Now this is true, but is not inconsistent with the limit concept, for the definition does not require that the function exist at the limit point. Therefore, the statement which follows that

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[1] Aeberly, John J., "Calculus: A Trigonometric Procedure," School Science and Mathematics, Vol. 58, No. 1 (January 1958), p. 45.

[2] *Ibid.*, p. 44.

[3] *Ibid.*, p. 45.

[4] *Ibid.*, p. 51.

the true value of e cannot be obtained with the increment h is an unjustified conclusion. Similarly, the definition

$$e=\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$$

does not say that the function exists at $n=\infty$

Next, consider the concepts of Δx, Δy, dx, and dy. Δx is defined as a variable, just as x and y are variables. Δy is also a variable which is defined as a function of x and Δx by the following relation:

$$\Delta y=f(x+\Delta x)-f(x).$$

When x is an independent variable, the following definitions of dx and dy are used:

"(a) dx, called the 'differential of x', may be any real number whatever; that is, dx is another independent variable and its range is $-\infty < dx < \infty$, and
(b) dy, called the 'differential of y', is a function of x and dx given by $dy=F'(x)dx$, where $F'(x)$ is the derivative with respect to x of the function $y=F(x)$."[5]

The derivative $F'(x)$ is defined by:

$$F'(x)=\lim_{\Delta x\to 0}\frac{\Delta y}{\Delta x}=\lim_{\Delta x\to 0}\frac{F(x+\Delta x)-F(x)}{\Delta x}.$$

This definition does *not* say that $\lim_{\Delta x\to 0}\Delta x=dx$ nor does it say that dx can be defined independently of dy. Also, it must be remembered that the variable dx does not mean d times x, but is a single symbol, written in this form as it is often used in close connection with the variable x. Thus, dx and dy are adequately and logically defined, and do not violate the fundamental rules of mathematics.

On page 47 of the article, however, it is asserted that

$$\text{“}\lim_{x\to 0, n\to\infty}\Delta x=(1/n)x\text{”}$$

This is equivalent to saying that $\Delta x=0$ and may not, as implied, be substituted for the usual definition of the increment. Furthermore, it is stated that equation #2 (page 50) "shows (Δx) approaching (dx) as a limit."[6] Again, this is not consistent with the usual definition.

Now that it has been demonstrated that calculus does not violate any mathematical principles in defining the limit process, the differential, and the derivative, it is worthwhile to consider the development of the new method presented. This process of differentiation is based on the following concept: ". . . the tangent to the curve is not obtained by the infinitesimal approach to zero, but instead it is

[5] Thomas, George B., Jr., *Calculus*, Addison-Wesley, Cambridge, 1953, p. 65.
[6] Aeberly, *op. cit.*, p. 51.

reached by dividing the dependent variable as often as (x) is contained therein."[7] This statement is hard to interpret, especially when applied to such functions as e^x and $\sin(x)$. In order to be precise, this process of differentiation needs to be expressed symbolically in the general case for all functions to which the method is to be applied.

Following the verbal explanation of the process is an example which is climaxed by the following equation:

$$\text{“}4y/x = 4x^3\,\frac{x}{x} = 4x^3(1^2) = 4x^3\text{”}$$

It is asserted that the last expression is the conventional value for $d(x^4)/dx$ when the value "(1^2) has been dropped," although the significance of this symbol 1^2 is never explained. Although $4x^3$ is the derivative of x^4, one example doesn't prove a theorem, and the relation between the algebraic manipulation and the common definition of differentiation using limits needs to be demonstrated for the general case, and a mathematical proof that the two processes are equivalent should be supplied. Furthermore, the significance of the special symbol "1^2" and the "$(1^2 \rightarrow 0)$" which appears later in an equation on page 49 should be made clear as they are not used or defined in the ordinary development of differentiation.

The article asserts that "to obtain the infinitesimal value of the terms in equation B above, all of them must be multiplied by $(1/n)/(1/n)$ and (n) must be allowed to approach infinity as a limit."[8] But $(1/n)/(1/n) = 1$, even as n approaches infinity. Thus this procedure is equivalent to multiplying by one, and if the equation yields the derivative after this operation, it does so before the operation. Consequently, it would seem advisable that this last operation be omitted as it fails to give rise to anything new and can only lead to confusion.

Next, we wish to examine the following statement: "If, in the equation $dy/dx = f'(x) = \tan\theta$, we substitute this last term $(4x^3)$ for $f'(x)$, we have an unbalanced equation since this value is not approaching zero as a limit."[9] If this means that $f'(x) \neq 4x^3$ where $f(x) = x^4$, then it is being asserted that the methods of differential calculus are wrong and a mathematical proof that there is a contradiction in calculus should be supplied. On the other hand, if "unbalanced equation" does not mean that the expressions are unequal this term should be explained. Only then may one understand the relevance of the fact that $4x^3$ "is not approaching zero as a limit."

Finally, there is some confusion surrounding the discussion of the

[7] *Ibid.*, p. 48.
[8] *Ibid.*, p. 49.
[9] *Ibid.*, p. 49.

angle θ and the relation between the algebra of the new method and trigonometry. For example, it is stated that the secant line from the origin to the point (1, 1), common to all equations $y=x$, forms an angle (θ) with the x-axis.[10] However, it is further stated: "When this secant line becomes coincident with the line tangent to the curve, which also passes through the point (1,1), a right triangle is formed. This triangle has (θ) as the angle under consideration and the side adjacent to this angle is the x-axis."[11] Generally speaking, however, the angle between the secant from (0,0) to (x,y) and the x-axis is not the same as the angle between the tangent line at (x,y) and the x-axis. Thus θ seems to be a variable which is somehow associated with the derivative. The nature of this association, which is presumably the basis for calling the method a trigonometric procedure, is not obvious and needs to be explained in greater detail.

In conclusion, we hope that the preceding criticisms show two things. First, the challenge directed at modern calculus has not been successful, because all arguments used have depended upon an evaluation of limits by direct substitution at the limit point—a process not condoned by the definition. Secondly, the proposed theory needs to be more completely developed before it can be fully understood. In its present form, mathematical methods are difficult to apply, because some of the basic definitions are lacking. Only when all procedures are put forth on a sound foundation can the full merit of the theory be realized, right or wrong.

[10] *Ibid.*, p. 51.
[11] *Ibid.*, p. 52.

CAN BUILD ATOMIC REACTOR INCAPABLE OF EXPLODING

An atomic reactor that will eliminate the danger of explosions can be built using a radically new device called the "convergatron," the American Nuclear Society meeting was told.

Dr. Lyle B. Borst, New York University physicist, said two new types of atomic power plants had been designed using the convergatron. One is a fast neutron breeder reactor, the other a natural uranium and water system.

Uranium and water cannot produce a full chain reaction regardless of their proportions, but they do make an efficient power plant with the convergatron. Dr. Borst said this system would never have a full chain reaction and could be operated by adding a few neutrons amplified to the level required for power production.

The convergatron is a neutron amplifier in which the neutron output is greater than the input. In a manner related to that of the vacuum tube, it magnifies the flow of neutrons. A series of convergatrons would amplify neutrons from a weak source to a large power reactor, yet the power plant itself would shut off upon removal of the source. Because all parts are subcritical, there is no danger of losing control of the chain reaction.

The convergatron consists of three sections: one containing the pure neutron moderator such as plain water or graphite, one containing atomic fuel such as uranium-238, and a thermal neutron barrier such as cadmium.

PLASTIC AND STRING MODELS OF REGULAR SOLIDS

R. F. Graesser
University of Arizona, Tucson, Arizona

There are five regular, convex polyhedrons. These Platonic or cosmic solids will be referred to as regular solids. The so-called fifteenth book of Euclid's *Elements* deals with the inscription of some of these regular solids in other regular solids.[1] The same topic is briefly discussed by Ball,[2] and is the subject of an article that appeared in this Journal.[3]

The present availability of sheets of transparent celluloid, plastic, and acetate makes it possible to construct many interesting models of such inscriptions. The circumscribed regular solid can be made of transparent material, and then the edges of the inscribed regular solid can be represented either by colored strings or by lines drawn on the faces of the circumscribed solid. Directions for working with these materials are available.[4] Transparent sheets 0.01 to 0.06 of an inch thick are usually satisfactory. These sheets may be "cut" along straight lines by first scratching them with a sharp point then breaking them by bending. Cement may be purchased or may be made by dissolving the material itself in some such solvent as acetone. Strings may be attached by inserting them in small holes, drilled or made with a hot needle, and then sealing them into the holes with cement. Two points will be called joined if they are connected by a string in this way. Lines may be drawn on the transparent faces of the circumscribed solids by using a Listo pencil with wax leads of various colors, or other similar pencil.

1. Tetrahedron in a cube. Figure 1. On the three faces about a vertex A of the cube draw the diagonals meeting in A. Draw three lines connecting the non-concurrent ends of these diagonals thus completing the tetrahedron A-BCD.

2. Cube in a dodecahedron. Figure 2. On the three faces about a vertex A of the dodecahedron draw chords from that vertex to alternate vertices. Draw these chords so that they are mutually perpendicular thus forming three edges of a cube. Repeat this operation at the non-concurrent ends of these three chords thus completing the cube.

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[1] Heath, T. L. *The Thirteen Books of Euclid's Elements*. Cambridge University Press 1908. Vol. III, p. 519 f.

[2] Ball, W. W. R. *Mathematical Recreations and Essays*. 11th Ed. Macmillan Ltd. 1939, p. 231 f.

[3] Hawthorne, Frank. "A Model of the Five Regular Polyhedra," School Science and Mathematics, 52, pp. 125–126, February, 1952.

[4] Cundy and Rollett. *Mathematical Models*, Oxford Press 1952, p. 74 f. National Council of Teachers of Mathematics. *18th Year Book* 1945, p. 233.

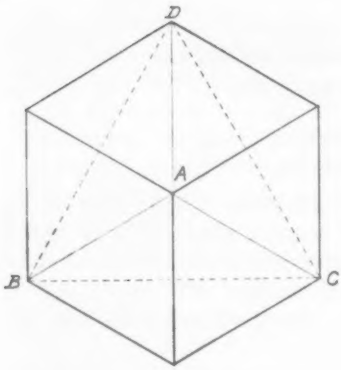

FIG. 1

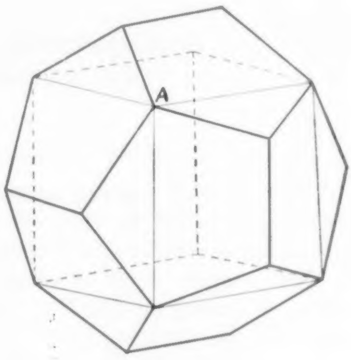

FIG. 2

3. Octahedron in a dodecahedron. Figure 3. Join with string the midpoint of any edge AB of the dodecahedron with the midpoints of the four edges perpendicular to AB. These latter edges are CD, EF, GH, and IJ. Join these last four midpoints to form the base of a square pyramid. Located the midpoint of the edge diagonally opposite and parallel to AB. Join this with each of the four vertices of the base of the square pyramid thus completing the octahedron.

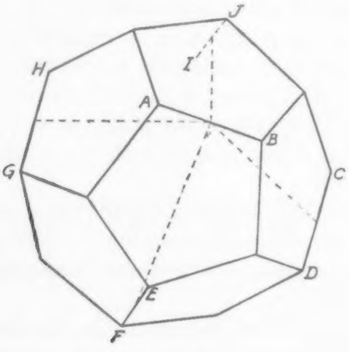

FIG. 3

4. Octahedron in an icosahedron. Exactly as in *3*, join the midpoint of any edge of the icosahedron with the midpoints of the four edges perpendicular to it. Continue with the same steps as in *3* thus completing the octahedron.

5. Icosahedron in a dodecahedron. Join the center of each pentagonal face of the dodecahedron with the centers of the five faces adjacent to it.

6. Dodecahedron in an icosahedron. Join the center of each triangular face with the centers of the three faces adjacent to it.

7. The other four regular solids in a dodecahedron. Follow the directions in *2*, *3*, and *5*, then use *1* to inscribe a tetrahedron in the cube of *2* by joining the vertices of the cube with string. Use different colored string for each of the four inscribed solids

8. The other four regular solids in an icosahedron. Follow the direct tions in *4* and *6*, then use *2* to inscribe a cube in the dodecahedron of *6* by joining the vertices of the dodecahedron with string. Inscribe a tetrahedron in this cube by *1* also using string. Different colored string should be used for each of the four inscribed regular solids.

It is not possible, using plastic and string, to inscribe all four of the remaining regular solids in either a tetrahedron, a cube, or an octahedron. In order to apply our method, it is necessary that each of the four inscribed solids have its vertices in the faces or edges of the circumscribed, transparent solid. This will not be the case if our circumscribed, transparent solid is a tetrahedron, a cube, or an octahedron.

9. Families of a regular solid in another regular solid. The inscriptions in *1*, *2*, *3*, and *4* are not unique, i.e., several such inscriptions may be made in the same circumscribed, transparent solid. When each such inscription is made with a different color, attractive and interesting models are produced. For example, by following *1*, it is possible to inscribe two tetrahedrons in the same cube. Since the edges of each of these tetrahedrons lie in the faces of the cube, each tetrahedron may be drawn on the faces of the cube with a different color. As another example, by following *2*, five cubes may be inscribed in any dodecahedron, since we may start with any one of the five chords in a face, and each one leads to a different cube. In each of these five inscribed cubes, we may use strings to inscribe two tetrahedrons making ten different tetrahedrons inscriptible in one dodecahedron. And so on. Table 1 shows some numbers of possible inscriptions by our method for representing solids. It should be noted that a tetrahedron may be inscribed in a tetrahedron, a cube in an octahedron, and an octahedron in a cube by connecting the centers of adjacent faces. Also an octahedron may be inscribed in a tetrahedron by drawing lines in the faces of the tetrahedron connecting the midpoints of the edges. An icosahedron may be inscribed in an octahedron by joining the points of golden section of the edges by lines drawn in the faces and then joining with string the pair of golden section points nearer each vertex. To locate a point of golden section, multiply the length of the edge by 0.618^{+} and measure this distance from a vertex. See Figure 4.

10. Axes of symmetry of the regular solids. An axis of symmetry is a

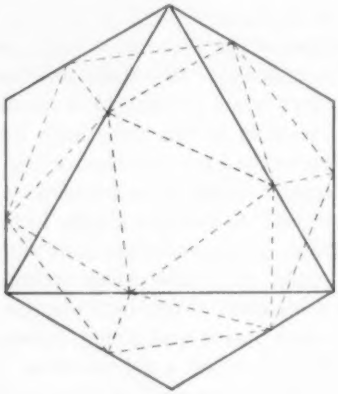

FIG. 4

TABLE 1. NUMBERS OF INSCRIBED SOLIDS

Circumscribed Solid	Inscribed Solid: Tetrahedron	Hexahedron	Octahedron	Dodecahedron	Icosahedron
Tetrahedron	1		1		
Hexahedron	2		1		
Octahedron	2	1			1
Dodecahedron	10	5	5		1
Icosahedron	10	5	5	1	

line about which a regular solid can be rotated into itself by a rotation of less than 360°. These axes are of three kinds as indicated by the column headings of Table 2, which also shows the numbers of each kind possessed by each regular solid. The total number possessed by each regular solid is one greater than the number of its edges. The different kinds of axes can be nicely shown by strings of different colors in transparent models of the regular solids.

TABLE 2. NUMBERS OF AXES OF SYMMETRY

	Joining centers of 2 faces	Joining midpoints of 2 edges	Joining 2 vertices	Joining a vertex and center of a face	Total number of axes	Total number of edges
Tetrahedron		3		4	7	6
Hexahedron	3	6	4		13	12
Octahedron	4	6	3		13	12
Dodecahedron	6	15	10		31	30
Icosahedron	10	15	6		31	30

EDUCATING THE HIGH SCHOOL STUDENT FOR ATOMIC DEFENSE*

EDWIN J. SCHILLINGER
De Paul University, Chicago, Illinois

These are trying days in the educational world. You and I, as science educators have been veritably shoved into the national spotlight. We are studied, examined, extolled, criticized, even blasted, for what we do or don't do, and how we do or don't do it. While this position is not an enviable one, it should provide the impetus to make us review our role in the society and re-examine each other and ourselves; and not too unenthusiastically, either.

The star performer, now occupying center stage in this examination, is science education. We are brought to task by some because of the declining numbers of scientists and engineers each year entering their essential professions. To be sure, the press, to its everlasting credit, does not make us bear the full brunt of the attack. The anti-intellectualism of our times has been singled out as the principal offender. But yet, we feel the rebuke of some, despite the efforts of those who defend our purposes, our goals and our methods.

True, there has been much sniping for many years. But this has been sufficiently muted by the apparent scientific and technological superiority of our nation. Now, however, Sputniks I and II have prodded us into the fishbowl of public examination.

While I am confident that our defense against these critics is objective, well-founded, rational and adequate, I feel that we will agree that we can find much room for improving our efforts. And the area which provides very much room for improvement is in the liaison between science teachers in high schools and in colleges. We have much to discuss and much to learn from each other.

It is for that reason that I responded so readily to Mr. Keil's invitation to speak today.

The invitation was extended last spring when we served as judges of General Science exhibits at the Chicago Public High Schools Science Fair. I do believe that he was sufficiently concerned over my attempts to judge the relative merits of a model of an atom-powered submarine, a homemade telescope and an undernourished white mouse that he almost forgot to ask me. I am sure he would have forgotten had he known that I studied General Science under an embryonic physicist who did not believe in Biology.

You probably are not aware of the fact that Mr. Keil was a member of De Paul's first Symposium on Atomic Defense just two sum-

* Paper presented at the Convention of the Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 30, 1957.

mers ago. It is a souce of satisfaction to know that his great interest in the subject was encouraged by our program.

Atomic Defense Courses

Being an apostle for courses on atomic defense is a satisfying and worthwhile endeavor. The work that we have done at De Paul and that many others have done at other colleges has convinced me that instruction in the general area of nuclear technology, modern weapons and civilian defense measures has a two-fold value that must appeal to every science teacher and patriotic citizen. Such instruction has a good, sound educational value (which to educators must be primary) and is a fine community service (which must not be ignored). I hope to convince you of the merit of courses on atomic defense and to urge you to introduce some atomic defense instruction into your curricula.

While I am most happy to be here with you today, I must admit to a feeling of uneasiness in discussing this general topic. The discovery of the explosive power of nuclear weapons certainly provided the background for these most trying days. For ten years, "the bomb" was acknowledged but conveniently ignored. The realization that others have matched our achievements makes it no longer ignorable.

A description of the catastrophe that would be a nuclear war is no pleasant task. One certainly runs the risk of being labeled a "prophet of doom." Yet someone must speak out: someone must dispel the comfortably false feeling of "it can't happen here." It would seem that our extremely good fortune in having been spared direct civilian casualties in prior wars has lulled us into a sense of complacency. Education in the means of waging modern warfare will shatter this dream. It is ironic to think that it takes a nightmare to do it.

If we, with the unwitting help of the two Sputniks, can overcome the apathy that has long blocked effective public instruction in matters of civil defense, we will be able to go a long way towards preparing our students, their parents and all members of the communities we serve for living with the facts of nuclear war.

Background

Your national government, through the Federal Civil Defense Administration (FCDA) has long accepted prime responsibility for preparing the nation for possible attack on civilian populations. Because, however, it has limited powers over state civil defense agencies, it left to the state agencies the problem of beginning and implementing all instructional programs.

Since the problem was truly one of education, the State of Illinois delegated to the Superintendent of Public Instruction the task of bringing awareness of atomic defense to the people. In September

of 1955 all colleges and universities in the state were asked to send representatives to a meeting designed to study the problem. The result of this meeting was the initiation of three types of civil defense courses.

The most important of these for long-range planning was the so-called "Background" course. It was intended to prepare high school teachers in this general area of instruction. The colleges and universities of the state were asked to offer all three courses in cooperation with the state but on an independent basis.

De Paul University responded to this request by offering concentrated, one-week programs during the summers of 1956 and 1957, under the title, "Symposium on Atomic Defense." We were quite eager to do this, as you will conclude from the remainder of my remarks, because we saw that the background course could be made into a worthwhile educational experience in science, because we would be providing a meritorious civil service, and because it would improve upon the liaison between our faculty and high school teachers

It was, of course, through these experiences that we came into direct contact with the problem posed in the title of my talk, "Educating the High School Student for Atomic Defense." The preparation of class material and conversations with the registrants led us to some very definite ideas of the topics which should be presented in any high school course in atomic defense. These, I shall list for you momentarily.

Before doing this, however, I would like to assure you that atomic defense programs in high school are an accomplished fact. Several of our 1956 registrants returned to their local schools and set up extremely successful curricula. One of our students initiated the first course in atomic defense in the high schools of Michigan. Also, several of the Sisters of Notre Dame returned to their Motherhouse in St. Louis and began atomic defense courses for members of their order. This began an excellent analogue of a chain reaction which made itself felt in the high schools served by them. I would feel confident in expecting that several others of the seventy-five students we have been privileged to teach have also set up courses specifically designed for atomic defense instruction. And I am equally confident that all the teachers in the program carried at least a little civil defense material into their regular classes, even if they did not initiate a special course.

Atomic Defense Course Outline

In implementing a decision to offer instruction in atomic defense you are faced immediately with the problem of how to do it and what to teach. There are two possible answers to the former question:

(a) teach a separate and distinct course, or (b) incorporate the material into your regularly scheduled classes. While it seems that the former would be more effective, the latter might be easier to do since it involves less administrational difficulties. Further, the idea of incorporating the material into existing courses has the added advantage of bolstering your course through the introduction of this topical and intensely interesting subject.

To answer the question of what to teach, I would submit the following outline of topics which should be covered in any presentation which is to be comprehensive. In elaborating on them, I will indicate content and suggest a level of presentation, at least by implication. It would be a mistake to anticipate that the level should be anything less than the highest possible. The science associated with the course is good tough science. Certainly the analytical problems must be ignored or simplified, but the concepts and descriptions so necessary for proper understanding of nuclear technology must be explored thoroughly and properly.

The topics which must be covered are:

1) General theory of nuclear energy.
2) Physical effects of nuclear explosions.
3) Radiological detection.
4) Biological and medical effects of nuclear explosions.
5) Civil defense counter-measures.

To these could be added point six: "Psychological effects of nuclear explosions." While this, to me, is a topic of extreme importance, it never appears in other course outlines. Certainly the problems raised by it are difficult because they are nebulous: after all, we have little experimental evidence on the reaction of American citizens to catastrophes of the magnitude of a nuclear holocaust. Then again, the exclusion of this topic might be a manifestation of the peculiar brand of escapism so prevalent today.

I should like to suggest, too, a point seven: "Peaceful uses of Nuclear Energy." This is obviously not essential to atomic defense but does provide you with a pertinent and optimistic extension of the material you have already developed.

What "Parent" Course?

If we assume that your decision is to incorporate atomic defense material into the regularly scheduled classes at your school, the question arises as to how to do it. Clearly the material could be distributed among Physics, Biology and, perhaps, Hygiene. The objection to this is that the presentation is too piecemeal. The effectiveness is bound to be unfavorably influenced by the necessary discontinuity of the system.

I would submit that the best way to teach atomic defense is to incorporate the subject into the General Science course. It is here that we find all the necessary topics. And, even more importantly, in this way the information is given a much wider dissemination.

Too Much Civil Defense?

Before elaborating on the topics in the outline, let me anticipate a possible objection that training in Civil Defense procedures does not properly belong in your courses. I must agree with this objection. But I also feel that it is but a small and justifiable compromise to include a minimum amount of it as a necessary community service.

It is not within the domain of education to deal excessively with the specifics of Civil Defense. It is the job of the FCDA to originate the plans for atomic defense procedures and to disseminate them to the people. It is our job to overcome the ignorance of the people in such matters. And this is the more important.

It is difficult, from a practical viewpoint, to teach much of the specific organization and procedures of civil defense. Any of you who have tried to do so will, I feel, agree with me. There is simply too much material to digest. There are too many aspects of the overall problem, too many publications devoted to each, too many too pat solutions to the problems raised for the teacher to pursue. And even if he did he might come to feel, as I do, that no one could remember all the advice he has been given. And, worse yet, that many of the solutions are too artificial and subject to change. Clearly the best example of that would be the stand, for many years, that our best hope of survival lay in evacuation of metropolitan areas. While this advice was good in the days of the propeller-driven airplane and the relatively small A-Bomb it is not good advice today, in the age of the H-Bomb and the intercontinental ballistic missile. It is only recently that the FCDA has admitted the limitations, of evacuation.

You can best render a service to your community by teaching science (and thereby dispelling ignorance and consequent unreasonable fear) and the rudiments of civilian counter-measures to attack. I am sure that the common sense of the American people will be able to function properly once we have performed this job.

The main and detailed procedures envisioned for use in times of catastrophe must be developed by the FCDA and learned and practised by our local Civil Defense Agencies. They cannot be adapted to the high school classroom in a practicable manner, particularly in regularly scheduled classes.

Topic I: General Theory of Nuclear Energy

In elaborating on the topics in our course outline we must cover

the general theory of nuclear energy first. Since this topic has the greatest scientific interest, I would expect that it would receive the most attention.

The barest essentials for a comprehensive presentation of nuclear energy would include the following points:

a) Properties of neutrons and protons
b) Nuclear mass considerations.
c) $E=mc^2$
d) Fission and fusion

Obviously there are associated subjects which you now teach and which you would want to add to this list, such as chain reactors. It is well to so add, but I feel that an understanding of nuclear energy can be had from a coverage of just these four points.

The most essential property of neutrons and protons is the mass. The astounding fact that it would take 6×10^{23} neutrons or protons to make just one gram of them is a worthy starting point. Although less essential but equally interesting is the size of these fundamental nuclear particles. The fact that it would require 25 million million neutrons, laid side by side, to form a column one inch long will certainly provide some insight into the magnitudes of the individual sources of nuclear energy. If you have previously described magnitudes in Atomic Physics, you can quite clearly compare the two scales of observation. It should come as a bit of a revelation to your students that it would take one hundred thousand neutrons, laid side by side, to form a column having a length equal to the diameter of the hydrogen atom. Clearly, matter is mostly empty space.

The description of these particles (and, indeed, of nuclei themselves) should be much more than mere cataloging. It is good science. For example, it is here that you can impart ideas about scales of observation by ranging from the stupendous magnitudes of Astronomy to the infinitesimals of Nuclear Physics. And this is a very worthy contribution to anyone's science education.

The next topic in our bare outline of Nuclear Physics would cover the way in which neutrons and protons combine to form nuclei. The key consideration is, of course, that mass "disappears" in the process. What happens to it requires some explanation of our third point, Einstein's classic equation, $E=mc^2$. It is here that you would affirm the conservation of energy principle, while modifying the older conservation of mass principle by incorporating it into the former.

The energy released during a fission or fusion process can be best analyzed by considering some specific examples. You could analyze the mass of the uranium 235 nucleus and the sum of the masses of two typical fragments. The simplest way to explain the energy re-

lease would be to start from spontaneous fission. To make the split plausible you would probably find it advantageous to embrace the descriptive but inadequate liquid-drop analogy.

To prove that I do not intend to deliver a lecture on science alone, I would indicate here that you can do as much or as little as you like in going from our present point to the massive explosive power of the "Bomb." Your main points are induced fission, neutron emission, slow neutrons, the chain reaction, critical mass and the use of this energy for explosive purposes.

In introducing fusion you would perhaps find it desirable to describe the process whereby the sun and the stars obtain their energy. And the problem of commercial utilization of this thermonuclear energy should prove of great interest, also.

There is a host of topics covering good descriptive nuclear science presented by our bare outline. You would certainly want to go beyond these essentials.

The resourceful General Science teacher will even want to extend his lectures to the application of nuclear techniques to other sciences, such as the radioactive dating of rocks, nuclear chemistry techniques, tracers in medical and other researches, and a growing list of commercial applications.

Topic 2: Physical Effects of Nuclear Explosions

The second topic on our list, "Physical Effects of Nuclear Explosions," provides an area to which as much time can be devoted as desired. Certainly you would want to mention, at least in outline form, the main effects of blast, heat and non-thermal radiation.

Ordinarily, discussions of blast and thermal radiation might be considered as outside the scope of a course in General Science. But both of these do provide the bases for the introduction of many concepts in science. Specifically, pressure, force and waves can be discussed and probably with much more interest than if they were presented simply as "concepts which we will apply later" or, worse yet, as abstract concepts.

Still more science can be taught under the heading of blast and heat. Oxidation processes in Chemistry could well be discussed. You may not know that a nuclear explosion liberates sufficient thermal radiation to set fire to a distant wooden structure but that the blast wave promptly extinguishes the blaze. This fact could lead to discussions of kindling temperatures and an analysis of fire as the combustion of gases.

While the connection is artificial to be sure, I would think that there is justification for introducing material about the structure of the Earth and Seismology under the heading of "blast." After all, the

A-Bomb set off within a mountain just this fall was designed to help determine the Earth's Structure, in connection with the International Geophysical Year.

The third main physical effect, non-thermal radiation, is one to which I suspect (and hope) you would devote much time, probably in answer to your students' demands if for no other reason. Here is an opportunity to delve into more Nuclear Physics. Here you can describe the properties and physical effects of gamma rays, alpha and beta particles and neutrons. Obviously theoretical considerations of the mechanism for emission are not suitable for high school courses. But there is available a host of descriptive material relating to the various rays and particles, their effects, and means of measuring their strange and wondrous ways.

All this material either incorporates within itself or leads quite naturally to our next topic.

Topic 3: Radiological Detection

In the area of radiological detection we have a field which could occupy a whole year's course. It is here that you will experience the most sustained interest. For it is here that you can bring in actual instruments. And, in all probability, you can acquire these instruments at no cost, as I shall mention shortly.

In addition to describing the more common detectors, as ionization chambers, Geiger counters, filmbadges, etc. you might well introduce some elementary concepts of electric circuits. At least some appreciation of the electronic circuitry of the more complicated detectors can be conveyed by means of a block diagram, even if you do not have the time or the inclination to go further.

It is within the scope of a course in General Science to teach the use of radiological detectors in making area-surveys. Not only does this provide you with an opportunity to teach the essentials of scale-reading, scaling factors and plotting, but it will be a significant contribution to our national efforts in Civil Defense. The FCDA is extremely interested in building up a very large group of possible radiological monitors—for obvious reasons.

Your area-survey work would be vastly enhanced were you to acquire competence in the use of radioactive sources. The use of sources always heightens interest through the unwarranted tension they create. There is no need of strong sources. A few millicuries will be sufficient for Geiger counter surveys, and such source strengths can be safely handled and conveniently stored.

Of course, these sources would enable you to expand your laboratory work since many of the basic experiments on radioactivity could then be performed, independently of the atomic defense instruction.

Topic 4: Biological and Medical Effects of Nuclear Explosions

The fourth item on our defense course agenda is the "Biological and Medical Effects of Nuclear Explosions." Since I know little about either Biology or Medicine, I would not presume to suggest to you how these topics may best be covered. Much first-rate science can be covered. For the purpose of atomic defense, the minimal coverage would include a description of the effects of radiation on the body, decontamination procedures and elementary first-aid against radiation damage.

Topic 5: Civil Defense Counter-Measures

In topic five of our list, "Civil Defense counter-measures," we essentially leave the field of science for the field of public service. If we agree to teach atomic defense then we must agree to teach at least the fundamentals of the existing counter-measures. Indeed, for practical reasons, it is imperative that you do so for, unless you do, in all probability, you will be ineligible to receive radiological equipment.

To give you some idea of the more important aspects of Civil Defense, I would submit the following list with relatively little elaboration:

1) Analyze the relative merits of evacuation and taking shelter for differing warning times, geographical locations and fallout predictions.

2) Impress upon your students the absolute necessity of taking shelter from blast and all radiations of a nuclear explosion.

3) Teach the need for remaining as calm as possible. Stress the fact that Civil Defense direction will come as soon as possible after the initial attack and that, until then, everyone must rely upon his own resources. The catastrophe will only be worsened if panic beclouds our common sense.

4) Tell your students of the advantage, yes even necessity, of keeping on hand sufficient supplies to provide for the family for at least a week. This would include; stocking a "grandmother's pantry" and making sure that the supplies are kept moderately fresh by proper rotation; and keeping bottled water in an accessible place and replacing this supply every six months.

5) Inform them of the existence of CONELRAD, at 640 and 1240 on the AM dial of the radio. In fact it would be wise to mark these positions indelibly since this will be our only means of the authoritative information which may insure our survival. Stress the importance of battery-operated radios, such as in the automobile, and that AC

operated radios will probably be rendered useless by power failure.

6) Emphasize that those houses which are not completely destroyed may be so severely damaged that existing exits may be of no value. Alternate avenues of escape must be planned to lessen panic. You must be prepared to leave the shelter of your basement in a minimum time if there is a conflagration.

7) Fires will be prevalent after attack and water supplies will probably be knocked out. This danger can be lessened, assuming a few minute's warning, by such simple expedients as shutting off electrical appliances and pilot lights, and putting out the fire in the furnace.

8) Make very sure that your students appreciate the necessity of remaining in a shelter during the time of fall-out, which may be several days.

9) Teach them the fact that the offending agent in fall-out is dust—radioactive dust. Thus canned and wrapped foods and bottled water will be safe if dust is kept from them during opening and eating. Also, if the dust settles on clothes, they must be promptly removed and laundered well in uncontaminated water, or discarded. Dust on the skin must be removed by extensive washing in pure water. Such water can be found in the home, even after attack and failure of the water supply, in hot-water heaters and water closets.

10) The very air that one breathes during the time of fall-out will contain radioactive dust. This danger can be lessened by the use of filters over the face or, better yet, over all apertures of the shelter. Any cloth which will keep out dust will make a fairly effective filter.

11) In going outside after the attack and subsequent fall-out, it must be realized that radioactive dust will cover all open surfaces. The clothes and skin will certainly pick up this dust and decontamination procedures must be followed upon return to the shelter.

12) Evaluate for your students the "calculated risk" that might need to be taken in performing rescue operations during fall-out periods. The rescue worker must know how much radiation he can "tolerate" and be able to weigh the good he can do against the risk to his own person.

13) It must be realized that nuclear attack will not contaminate large areas permanently. Certainly the area near the point of detonation, "ground zero," will be very radioactive for a long period of time. But the surrounding areas will be blanketed with materials which are relatively short-lived. Thus, the radioactivity level will probably reach a tolerant level in about a week. This optimism, unfortunately, does not take into account such dangers as the ingestion of the few, but dangerous, long-lived isotopes such as strontium-90.

14) While the ordinary citizen would not be expected to know how to make fall-out plots, such an activity might prove to be an interest-

ing part of your atomic defense course.

This, incidentally, could be introduced with an educational goal in mind. For the construction of a good plot demands the application of analytical methods which are most instructive.

15) It is a striking fact that many of the previous points covering counter-measures depend upon the proper use of radiological detectors for their effectiveness. That is, detectors ***which have been kept in good working order!*** This means that instruments must be periodically checked and that batteries must be frequently (every six months) replaced. Your students must learn the operation and care of these detectors. They must learn how they are used for such applications as determining the level of radioactivity in water and food, on clothing and the skin and in the general area in which they are sheltered. Such surveys are an integral part of the course.

These, then, are the topics of interest for civil defense counter-measures. A coverage of these items would insure the completeness of an atomic defense course and would provide the community service which is an integral part of the course.

Teaching Aids

To help you in the preparation and presentation of civil defense information, the several main Civil Defense agencies have made available to teachers, several aids which are indispensable for a course in atomic defense. These aids can be broken into three categories:

1) Specialized literature
2) Films
3) Equipment.

Specialized Literature

Several tons of reports, manuals, bulletins, pamphlets and folders on atomic warfare have been prepared by the national, state, county and city agencies. To help you find your way into this maze I have selected several publications which are not only most informative but also provide almost enough material to enable you to conduct a successful, even though minimal, course. Needless to say, I recommend them highly. They are listed below, together with their sources:

Supplier A: Superintendent of Documents
U. S. Government Printing Office
Washington 25, D.C.

Supplier B: FCDA
Battle Creek, Michigan

1) The Effects of Nuclear Weapons. (A). This is the very recent,

very complete and very readable account of all declassified information on the effects of nuclear weapons. It contains 597 pages of pertinent information and a bibliography, all for only two dollars.

2) Information for Food and Drug Officials (A). This manual, from the Food and Drug Administration of the Department of Health, Education and Welfare contains a readable summary of the scientific basis of nuclear weapons and effects, as well as living up to its title.

3) Civil Defense Urban Analysis Training Manual-8-1. (A). This is one of a series of training manuals, most of which are of some value in an atomic defense course. This manual emphasizes the zones of different degrees of blast damage for variously sized bombs.

4) FCDA Advisory Bulletin No. 188, with Supplements. (B). This bulletin, again one of many, provides detailed information on how fall-out plots are constructed.

I am tempted to say that these four references, when considered with your own scientific background, would provide you with sufficient information for your courses. However, it would be to your advantage to acquire:

5) Civil Defense and Atomic Warfare, a Selected Reading List: H-25-1, FCDA. (A),

which is a slightly outdated but still pertinent bibliography.

In addition to these you should acquire a good supply of maps (from your neighborhood gasoline station) and the Civil Defense Air Raid Instruction Posters which are probably posted in your schools right now.

Films

The second category of teaching aids would be motion pictures. Lists of those available, at no cost, may be obtained primarily from your state Civil Defense Agency. Other lists and the films themselves are obtainable from the following sources:

1) Your state film library
2) Fifth Army
   Central Film and Equipment Exchange
   Fort Sheridan, Illinois
3) U. S. Atomic Energy Comission
   Chicago Operation Office
   P.O. Box 59
   Lemont, Illinois

I would recommend highly the use of films in any course you might initiate. Of special interest are those dealing with the various nuclear weapons tests and the Civil Defense exercises conducted in conjunction with these tests. In describing the awesome power of these weapons, one picture is worth many thousands of words.

One word of caution is in order in requesting films. There are many available and many are duplicatory, not pertinent or not suitable for the desired level. Your time in class is too valuable to be lost on unsuitable films, so choose them with care.

Equipment

A very integral and interesting part of an Atomic Defense course is the section on radiological instruments. These, of course, are too often beyond the financial means of a General Science department. For that reason it is possible for you to obtain these instruments on a "Permanent Loan" basis, with title held by your local Civil Defense Director. The number of instruments so obtainable is determined by the size of your class and is rather small.

You can borrow a demonstration kit for several days, if needed. Usually such a kit contains about 20 detectors and thus provides enough instruments for monitoring and field exercises.

The best way to obtain the equipment on permanent loan, or the exercise kit, is through your local Civil Defense Director. Since procedures vary from region to region I would suggest that you contact the local director or the State Director to obtain the necessary information.

While your Civil Defense Agencies are anxious to provide this equipment, it is important to note that certain conditions must be met. These are:

1) Your class must have a minimum of approximately twenty students.
2) You must be qualified. That is, your previous education should indicate your competence with the instruments to be entrusted to your care. If your background in this area is limited you can become qualified by attending a certified "Monitor's" course offered usually by some College or University.
3) Your course of instruction must be approved. This means that the special course you offer, or the material you intend to incorporate into your regular courses, must meet the minimal requirements for content as set down by the FCDA. I do not think that this will present any difficulty at all.
4) Your school must be in an area served by an accredited Civil Defense Organization.

Conclusion

The initiation of instruction in atomic defense in your school will require a fair amount of effort. The end result is, however, rather richly rewarding and, I think you will find, as interesting to you as it is to your students.

All the help you need in organizing the materials for a course will be provided, most probably, by your State Civil Defense. In Illinois, you should contact:

Mr. Merle G. Moore
Civil Defense Coordinator
Office of the Superintendent of Public Instruction
Room 304, State Office Building
Springfield, Illinois

I would repeat my earlier request that you give serious consideration to the educational value of a course, or of course material in General Science, covering Nuclear Technology and Atomic Defense. Further, I would hope that you treat the course at an appropriate level and not present it as a community training activity. The scientific topics in the course outlined here presented are teachable, sufficiently challenging and fairly non-analytical. Certainly we must challenge and we must interest our students in science. If we succeed in this we will be fulfilling our designated role in keeping this country in its position of scientific leadership.

NYLON TUBE MAKES NERVES GROW AGAIN

The regrowth of an adult animal's spinal cord has been made possible by the use of a special nylon tube that surrounds the two severed ends.

The nylon tube is impregnated with cellulose acetate and forms a scaffolding which appears to allow the orderly regrowth of the many nerve fibers in the cord until they close the gap.

The structure of nylon is such that it allows necessary body fluids to pass through and nourish the regrowing nerves, but it keeps out tissue cells which might otherwise invade the area and stop the repair.

In cats, the nylon tube caused the ends of the spinal cord to be firmly joined by a bridge of tissue within 30 days.

Microscopic examination showed that the separate fibers were regenerating in an orderly fashion within the gap.

The same technique has also been used for repair of outlying nerves in the animal body. Because of it, the nerves have begun working again 70 days after a one-inch gap was repaired.

It is still too early to tell, though, how much function will return to the spinal cords after they have grown back together.

EVEN SEAWEED HAS CHOLESTEROL PROBLEM

Cholesterol, thought to be only a problem for man and animals, has just been found in vegetables, too.

Three Japanese researchers of the University of Tokyo and of the Sankyo Company, Tokyo, reported discovery of the fat-like substance in several red seaweeds.

Chemical and X-ray analysis of a compound in the seaweed proved it be to cholesterol. The finding was reported in the journal *Science* (Nov. 1) by Kyosuke Tsuda, Saburo Akagi and Yukichi Kishida.

BUILDING BACKGROUNDS FOR IMPROVING READING IN ELEMENTARY SCIENCE

MARY E. CEDARS
Roosevelt School, Kokomo, Indiana

The range of experience which a child has is often so narrow he seldom understands what he reads in his textbooks. To provide experiences which would supplement the cultural background of pupils coming from underprivileged homes so that they could better understand the printed material in their science books was the teacher's problem. As she planned the following activities for experiences, she was aware of the fact that boys and girls are scientists. They explore and discover, search for facts, and are curious. They have problems, ask questions, and want to find things out. They are taught to go to books to help find their answers. The teacher tried to use the pupils' natural abilities in helping them build concepts and strengthen scientific attitudes.

As a guide in the procedures, the thesis of Dr. L. B. Sharp, Director of Outdoor Education, Incorporated, was used. He stated: "That which can best be taught inside the schoolrooms should be taught there, and that which can best be learned through experience dealing directly with native materials and life's situations outside, should be learned outside."

The schoolroom described is at the Roosevelt School, Kokomo, Indiana, in a modern ranch-type building. It is a corner room, with the top part of the east wall and all the south wall made of glass. A plexiglass dome is in the ceiling just outside in the hall. The entrance to the building is a few steps away, so the pupils can observe the sky and use the outdoors as a part of the classroom at any time.

Most of the activities and experiments described were worked out by the teacher. She learned that it takes a variety of experiments, usually with simple things, for concepts to grow. The basic areas used were air (weather), rocks, soil, wildlife, wood and stars.

"Evening red and morning gray
Sends the traveler on his way;
Evening gray and morning red
Will bring rain upon his head."

This weather-wise saying about sunsets guided many of our pioneers as they planned their daily tasks. For years they did not know why it was true, but through experience with weather conditions they learned to rely upon it.

Why not use it to help boys and girls in the fourth grade plan their daily activities and understand weather? So at the first of school the teacher said this rhyme and encouraged the pupils to watch the sun-

set. Where would they look for it? What direction was it? What colors were in the sunset? All this the boys and girls observed and reported. They learned that if the "sunset" were gray, it was usually due to stratus clouds which were like a sheet or blanket across the sky. "What are the other clouds?" they asked.

As the different cloud formations appeared, the teacher introduced them. It was fun for the boys and girls to find pictures and descriptions of them in their books. From experience they learned: "Mares' tails (cirrus clouds) are advertising agents of bad weather." "Mackeral sky, not long dry." "Cumulus clouds are fair weather clouds," for "If woolly fleeces spread the heavenly way, no rain be sure, disturbs the summer day."

"We are learning to read the sky!" one of the pupils remarked as they observed the clouds one day. Then they began looking at the grass each morning, for:

"Rain will not soon follow dew, nor frost."

The Bunker Hill Air Force Base is only fourteen miles away, so the boys and girls watched the jet planes fly high in the sky, and go in and out of clouds. Since they followed "Space-Cadets" and other TV programs about space, they were interested in the Stratosphere and other parts of the atmosphere. So a pole that extended from the floor to the ceiling was divided into the Troposphere, Stratosphere, Ozonosphere, and Ionosphere, with a colored drawing of an Aurora Borealis at the top. A circle around the pole on the floor represented the Lithosphere, or the Earth. Since weather takes place in the Troposphere, the pupils pasted drawings of the clouds in that area, the cirrus at the top and fog at the bottom. Children live on the growing edges of our culture, so space travel is real to them. With tubular balloons space stations were made and hung from the light fixtures.

Measuring one another's shadows on the hard-surfaced court was an activity enjoyed on the same day and hour for three consecutive weeks. The pupils did not realize what was happening until their measurements were charted as bar graphs on squared paper. How surprised they were to see the lines grow progressively longer for each week. This helped in understanding why birds were flying south, trees were shedding their leaves, monarch butterflies were going south, ants with wings were swarming around, coccoons were being made, and seeds were being scattered. They enjoyed reading about the preparations for winter.

By locating the sunsets, the children knew that the sun seemed to be going southward. On September 21 they were pleased to see it set due West. A few of them saw the sunrise in the due East. With outstretched arms they pointed to the places for each While one child held his arms back, pointing to the sunrise and sunset for June 21,

another child walked around him. The boys and girls saw that the shorter distance between the arms represented the hours of darkness at night, and the longer distance represented the hours of daylight. They worked out the positions the sunrise and sunset would gradually have until the first day of Winter, December 21; and then for March 21, or first day of Spring; and on to June 21, or first day of Summer again. This helped them understand and develop a vocabulary about the Seasons. They knew why September 21 and March 21 were called the time of the Equinox.

On the first day of Autumn, the teacher read the poem, "The Weather Factory" by Nancy Byrd Turner. The boys and girls loved it, and learned it.

After returning to Central Standard Time, the stars were out before the children went to bed. The teacher showed them how to find the North Star or Polaris. One should stand, facing North, with right arm outstretched so that it touches the nose and mouth. Look beyond the pointer finger at the North Star. (Illustrate.) After a few days, almost every pupil reported that he had found it. Beginning with the North Star, the teacher showed the boys and girls where to point to locate the first magnitude stars in the sky. Gradually most of the boys and girls knew these by name and the constellations. Use of the Spitz Planetarium helped, too. They enjoyed using it so much that they each punched holes in the end of a tin can to represent stars in certain constellations. With a lighted flashlight inside the can, this was projected on the wall or ceiling. Stars were watched, read, and talked about all school year.

The children loved to bring in rocks. They liked to test the rocks that sparkled by rubbing them over glass. If the glass was scratched, the rock had quartz in it. Since Kokomo is in a limestone area, many of the rocks were limestone. By dropping a weakened solution of hydrochloric acid on their rocks, they discovered which ones contained lime, for they would bubble. Vinegar and carbonated water reacted to the limestone, too.

The boys and girls were surprised to learn that soil came from rocks. The teacher taught them to look for cracks, holes, and scratches in rocks, which are signs of erosion. They performed the following experiment. Put a small can of soil into a bucket of water; stir until it is all muddy. Skim off the bubbles and particles that rise to the top. These show that air, and pieces of plant and animal materials are in the soil. They are called humus, and give it richness and fertility. Stir the water again and pour it into glass jars. Watch this muddy water as the mud settles to the bottom. This is called clay and helps hold the parts of the soil together. Pour what remains into a seive. Wash it with water until all the muddiness is gone. What remains is

bits of gravel and rocks which give the soil drainage. This helped the boys and girls gain a respect for soil and Time.

During corn-picking time the boys and girls brought in cornhusks and cornstalks. They made cornhusk dolls, having fun with them as pioneer children did. Cornstalk fiddles and their queer tunes gave many experiences with sound. One end of the fiddle was placed in a pan, and the pupils noticed the volume when it was played. By adding water to the pan, it was amazing to notice the volume had increased.

For two years during rabbit-hunting season, children brought in rabbit skins and tanned them. The first time, one of the boys showed us how his father taught him to do it. After stretching and fastening the skins to boards, the children scraped the tissue away with knives and stones. It was remarkable to discover that Indians scrapers were easier to use, for they did not tear the skins. Salt was then rubbed in, and the skins were crushed in the hands to make them soft. This activity gave many understandings for reading and studying about Indians and pioneer life.

The teacher discovered that she could help the boys and girls become more interested in the study of nutrition by teaching them about their teeth. They used films, and a skit called "The Talking Tooth." The game "Vitamingo" from the Dairy Council let the children check up on their own food habits. Reading in their health book had a personal meaning.

Healing as shown by scars seems to be one of the remarkable things human bodies can do. Boys and girls talked freely about their scars, and for some it was a release. Then they went outdoors, looked at the the bark of the trees, and the scars they had healed. How did they do it? The pupils read not only to learn about the health of their own bodies, but about the growth of trees, too.

Using the International Geophysical Year as the theme, a mobile was made and hung from a light fixture in the schoolroom the middle of September, 1957. Designs of paper were made to represent the sun, stars, earth, moon, satellites, clouds, water and atmosphere. The boys and girls were interested in the I.G.Y. and amused to learn that man was studying the earth in order to leave it!

When the satellite Sputnik I was launched, they talked about it as if it were an expected accomplishment.

Using the model scale worked out by Dr. Harry Milgrom, supervisor of elementary science in New York City schools, the pupils worked out the relationships of sizes and distances for the earth, moon, and satellite Sputnik I using balloons. The scale 800 mi. = 1 inch was used for the model.

Actual	*Model*
Earth—8000 miles, diameter	10 inches
Moon—2000 miles, diameter	2½ inches
Distance earth to moon, 240,000 miles	25 feet
Sputnik I—24 inches	½ millionth inch
Orbit Sputnik around earth	34 inches in circumference

Sputnik I was shown on the wire orbit as a tiny ball of aluminum foil with two pins through it.

This activity delighted the boys and girls so much, they wanted to share it by showing others. They reported facts about the satellites given over radio, TV and in the newspapers.

The basic materials of Social Studies are science materials. Dr. Howard Lane, a professor in New York University, stated, "A child who has not helped anything grow is greatly handicapped." So to help learn more about people in different parts of the world, and how they live, seeds of plants grown were collected and planted by the children. Sawdust from the school workshop was used instead of soil so the seed germination could be observed. Cotton, grasses for hay, citrus fruits, corn, soybeans, wheat, rye and oats were grown. The sayings, such as, "Plant wheat in dust and oats in mud," and "Plant corn when dogwood is in bloom" became meaningful and helpful in understanding farming as described in the social studies books.

With these activities, and others, the teacher is trying to help her pupils to be free,—to learn, to read, and discover on their own.

ORAL INSULIN MAY PREVENT DIABETES

Preventing active diabetes from developing in people known to be susceptible to it may be possible with Orinase, the new insulin-replacing drug that can be taken by mouth.

A large-scale study of the drug as a preventive has been started by Dr. Riley Thomas, Howard University Medical School, on pre-diabetics who are not yet ill with the disorder but who may become active diabetics in the future.

These people are susceptible to diabetes because either one or both of their parents were diabetics and have passed on the hereditary weakness. About 25% or 30% of them do become active diabetics sooner or later.

Under normal conditions, their insulin production is adequate, but if they eat too much of sugar-containing foods, the excess sugar cannot be handled by the body and begins to show up in the urine.

As these "spill-overs" continue to occur, the body is able to produce less and less insulin and the person then becomes an active diabetic who requires insulin injections.

Diabetes-susceptible persons can be spotted by the use of the glucose tolerance test, in which injections of a sugar solution are given. If the pancreas is not able to supply the normal amount of insulin, excess sugar appears in the urine.

Orinase will probably be able to reverse the results of the glucose tolerance test in some of these individuals and will be given to them periodically.

The drug seems to revive the insulin-producing cells of the pancreas and enable them to produce more of the necessary insulin.

Follow-up studies done on these cases five, ten or more years from now will show whether the drug is effective in preventing active diabetes.

PATHS OF PROJECTILES

ROBERT C. YATES
The College of William and Mary, Williamsburg, Virginia

The family of parabolic trajectories of projectiles fired from a fixed gun has some interesting features. It is assumed that there is no resistance to the projectile in flight, that the gun has a constant muzzle velocity V, and that all action takes place in a vertical plane with gun at the origin of coordinates. The projectile is fired at an angle of elevation, θ.

Since the only force acting on the projectile in flight at (x, y) is the constant force of gravity (acting in the negative Y-direction):

$$m\ddot{x}=0 \qquad m\ddot{y}=-mg,$$

whence

$$\dot{x}=V\cos\theta \qquad \dot{y}=-gt+V\sin\theta,$$

and

$$x=(V\cos\theta)t \qquad y=-\frac{g}{2}t^2+(V\sin\theta)t,$$

or, eliminating t for the rectangular equation of the paths of projectiles:

$$(x-k^2\sin 2\theta)^2=-4k^2\cos^2\theta(y-k^2\sin^2\theta), \qquad k^2=\frac{V^2}{2g}\cdot$$

This is a family of parabolas with parameter θ. The following items are readily obtained and form good exercises for college classes.

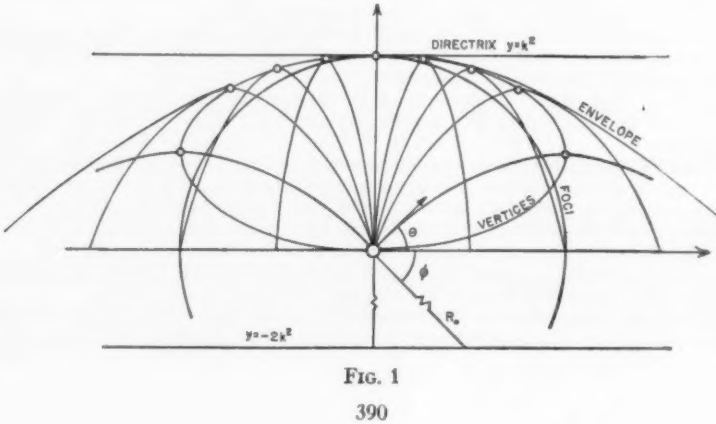

FIG. 1

1. *Latus Rectum:*

$$\boxed{4k^2 \cos^2 \theta}\,.$$

2. *Directrix:*

$$\boxed{y = k^2}$$

which is fixed for all angles of elevation θ of the gun.

3. *Vertices* have coordinates:

$$x = k^2 \sin 2\theta, \qquad y = k^2 \sin^2 \theta = \frac{k^2}{2}(1 - \cos 2\theta),$$

all of which lie on the *Ellipse:**

$$\boxed{\frac{x^2}{k^4} - \left(\frac{2}{k^2}y - 1\right)^2 = 1}\,.$$

4. *Foci* have coordinates:

$$x = k^2 \sin 2\theta, \qquad y = -k^2 \cos 2\theta$$

all of which lie on the *Circle:*

$$\boxed{x^2 + y^2 = k^4}\,.$$

5. *Envelope:* Writing the equation of the parabolas in the form

$$x^2 \tan^2 \theta - 4k^2 x (\tan \theta) + 4k^2 y + x^2 = 0$$

we have

$$\tan \theta = 2k^2 x \pm x\sqrt{4k^4 - (4k^2 y + x^2)},$$

a form which gives the angle θ of fire to hit any specified point (x, y). For given x and y,

$$4k^4 - (4k^2 y + x^2) < = > 0$$

yield respectively *no* angle θ, *one*, *two*.

Thus

$$\boxed{4k^2 y + x^2 = 4k^4}$$

* Notice that for maximum range, $\theta = 45°$, the vertex of the path lies at the end of the horizontal diameter of the ellipse.

is the parabolic umbrella which evelopes the trajectories and encloses the zone of fire.

6. *Centers of Curvature at the Origin.* From the equation of the paths,

$$(x-k^2 \sin 2\theta)^2 = -4k^2 \cos^2\theta(y-k^2 \sin^2 \theta),$$

the first two derivatives of y with respect to x are given by

$$x-k^2 \sin 2\theta = -(2k^2 \cos^2 \theta)\cdot y'$$

and

$$1 = -(2k^2 \cos^2 \theta)\cdot y''.$$

At the origin (where $x=0$),

$$y_0' = \tan \theta, \qquad \frac{1}{y_0''} = -2k^2 \cos^2 \theta.$$

The radius R of curvature at the origin is thus

$$R_0 = \left[\frac{(1+y'^2)^{\frac{3}{2}}}{y''}\right]_0 = -\sec^3 \theta \cdot 2k^2 \cos^2 \theta = -2k^2 \sec \theta.$$

If R, ϕ are polar coordinates of these centers of curvature, then, since $\theta = (\pi/2)-\phi$ (See Figure),

$$R = -2k^2 \sec \theta = -2k^2 \csc \phi$$

or

$$\boxed{R \sin \phi = -2k^2},$$

the *straight line*

$$\boxed{y = -\frac{V^2}{g}}.$$

7. *Bombing.* If the gun were located at (x_0y_0) instead of the origin we would have

$$x-x_0 = (V \cos \theta)t, \qquad y-y_0 = -\frac{g}{2}\cdot t^2 + (V \sin \theta)t.$$

These equations enable us to discuss certain problems in low-level bombing. If, for instance, the plane flying V miles per hour, has a flight angle θ (between 90° and 270°) and the target is at the origin

then t is the time it takes the bomb to travel from the release point (x_0, y_0) to the target. Setting $x=y=0$ and eliminating t:

$$\boxed{y_0=\frac{g}{2V^2\cos^2\theta}\cdot x_0^2-(\tan\theta)x_0},$$

the parabolic locus of points (show dotted) at which bombs may be released to hit the origin.

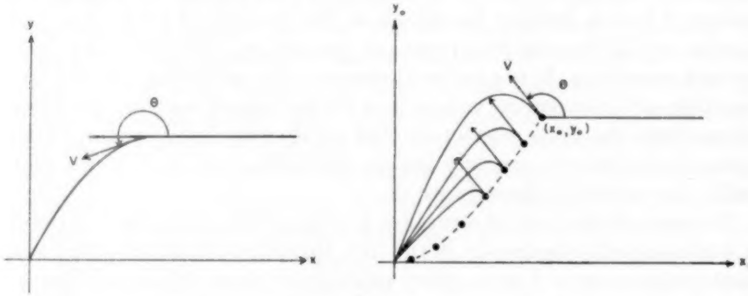

FIG. 2

TINY X-RAY UNIT SPOTS FLAWS IN ROCKET FUELS

A new technique for locating potentially disastrous flaws in cast charges of solid rocket fuels has been developed by engineers who use a small "extension arm" of huge X-ray generators to photograph the fuel from inside out.

Until now inspection of cast solid fuels has been a difficult, costly process involving wrapping X-ray film around the cylinder of fuel and passing X-rays completely through the fuel. The X-ray intensity was greatly reduced by passing through the entire fuel thickness.

The new technique involves transmitting high voltages from a large Van de Graaff X-ray generator to a small electron tube inserted in the "burning hole" running through the center of the fuel charge. Because the X-rays start at the center of the charge and pass through only half the fuel thickness, penetration requirements can be cut by 50%, and clearer pictures result.

EFFECTS OF GIBBERELLIN VARY WITH PLANTS

Gibberellic acid, a growth promoting substance originally isolated from rice, may not always increase a plant's growth.

The chemical may cause an increase in growth, a decrease or, even, have no effect at all. Each of four different plants reacted differently when gibberellins were added to their food.

All the tests were made on cultures of plant tissue in vitro, or grown "in glass," not on normally growing, whole plants.

Gibberellic acid's effect depends on the plant species, the part tested and the type of tissue. Based on exploratory study, "no generalities" can be drawn concerning the effects of gibberellins on plants. However, new studies in which the medium is varied along with the type of tissue tested and its source should be helpful in discovering what growth changes are caused by gibberellic acid.

THE PLACE OF NATURE IN MAN'S WORLD*

PAUL SHEPARD, JR.
Knox College, Galesburg, Illinois

"The place of nature in man's world" is a title borrowed from E. G. Murray of McGill University. Mr. Murray was describing to the St. James Literary Society the enormous impact of the smallest microbes on the destiny of man. There is a hint of sarcasm in such a title, in the image of nature shifting for herself in the humanized landscape; but not too much, because bitterness and pessimism contribute very little to understanding. It is a satirical phrase—the naturalist's rueful recognition of topsy-turvy values in a technological society. Its irony stems from the deep conviction that we do not change natural laws nor conquer nature; we only impose ourselves on it and, in the end, suffer for whatever damage we do.

Perhaps the role of conservation is to ease this impact and to point a way to avoid catastrophy in the frenetic rush to develop energy and material resources. The corollary problems of moderation and saturation in our individual consumption, and the pursuit of sensualism in speed and superfluous goods must be left to some occasion for the discussion of personal morality.

It is often maintained that conservation's objective is to increase efficiency, to demonstrate the best possible use of resources, and to discover new ways of feeding the machines of our productive enterprises. No one wants waste. A view of conservation as productivity and efficiency is harmonious with technology, materialism, and the philosophy of objective positivism. Our Greek-Roman, Hebrew-Christian world was created for man's use. In the past this world was formidable and hostile, where the fullest use of every tool yielded little more than essentials. Now, given tools of awesome violence and almost unlimited control, the choice of direction and intensity of our authority is much wider and we are compelled to reconsider the meaning of the "best possible use."

More and more frequently we see where the proper use of one resource is destructive to another. Good forestry does not prevent the pulp mill from poisoning the stream; good flood control may be poor agriculture; and at least on one occasion good aerial insect control has destroyed a lifetime of work on an experimental farm. We are specialists in soil, water, wildlife, and timber. It is no reflection on any individual forester that he cannot control the pollution by the mill any more than he can be held to account for the eventual use of the paper made at the mill in printing sleazy advertising. If the development of

* Presented to the Kentucky Conservation Council, Cumberland Falls State Park, Oct. 25, 1957.

a timber resource follows a sustained yield plan and the wood is transformed in an orderly way into energy or materials, one may point with pride to jobs the operation provides and the money it keeps circulating. In this and other fields of resource use, even where conservation management is in effect, there is evidence that we are drawing upon an annual increment in our intensive operation but still living off principal in a more extensive area influenced by the enterprise.

So long as the scale of resource use has been small, there was a healing and protective margin. The wildlife displaced in good or bad agriculture was replaceable, the bottomland soil inundated in stream management or its absence was superfluous. However, we learn that there will be 40 million more Americans added to our population in the next 13 years. At the same time that the extra space is diminishing, the scope of land use programs being undertaken is growing. "Good" highway engineering and sprawling suburban growth are devouring agricultural lands on a national scale at the rate of more than 25 million acres a year. Irrigation specialists in Arizona recently proposed to deforest a whole watershed. The future is presaged in an article called "Control of the World Environment" in which the head of the Minnesota Institute of Technology, Athelstan Spilhaus, expressed his discomfort in a world with some "empty" space left. He seriously proposes that huge areas be enclosed under roofs, that the hydrological cycle be "adjusted," that ocean currents be deflected to alter inland climates, and he advocates tinkering with the atmospheric radiation causing the glow in the night sky, to produce perpetual daylight. At a time when the journalistic passions are aflame over artificial satellites and tabloid writers prate of "conquering the universe," these manipulations of the world environment may seem small and all the more routine to many people. Controlling the world's environment is the dream of action complementing the industrial and Madison Avenue dogma of better living through higher consumption. In his artificial hydrological food factory, Spilhaus says, "One would merely put plant nutrients in and take human nutrients out." Current experience in hydroponics do not bear out the rosy optimism of this view. A limited variety of expensive vegetables are produced. Plant physiology and soil chemistry, not to mention the hydro and meteorological maze of the water cycle, have a way of withholding their ultimate secrets. The dream of total control of the world environment has psychic overtones which are not pleasant to contemplate, of a kind which, when expressed politically, are considered totalitarian.

There is a common rebuttal to those who are apprehensive of technological violence. Would we have the coal companies continue to rip up the landscape in strip mining to have heat, light, and other

coal products, or would we choose the short, savage, and filthy life of primitive existence more in harmony with primeval nature? Not even the simple act of building a fire is possible without some disturbance to the natural community. Some form of this alternative is ordinarily given to the conservationist today. He may flourish as a member of the big teams—big agriculture, big forestry, big flood control, big industry, even big wildlife management—and devote his energies to the solution of problems arising within and because of a violent and exploitive force-feeding of nature, or he may retire from the mainstream of life of the company of George Catlin, John Muir, Henry Thoreau, Joseph Krutch, and Olaus Murie, a group who are outside even of that select minority recently termed "The Outsiders" by Colin Wilson. After all, Mr. Wilson's "Outsiders" share with the mob the view that only what happens to man is of any genuine interest. Dominance over our environment is the jewel in the crown of human divinity entailed to us by the Greeks. It is common knowledge to every high-school boy that science has given us the joys of controlled violence of fire under forced draft, exploding gasses, jet forges, super-heated steam, high-voltage electricity, and the bombardment of atomic nuclei. Some college freshmen, however, are astonished to discover that some scientists have serious misgivings about the application of these discoveries, and about their egocentric literary and philosophical extenuations. In reply to a major liturgy on human genius in the *Saturday Review of Literature*, entitled "Think of a Man," Alfred G. Etter, Director of the Clopton Experimental Farm at Clarksville, Missouri, wrote: "I am not much concerned that atomic and hydrogen bombs may destroy mankind. I owe my allegiance to the whole world of life. The disappearance of a single species is of small importance when two billions years of creation hang in the balance. . . . We are not the owners of life. We are part of it. As I watch the eagles search the Mississippi I ponder their meaning—their bold harpooning of the shad, their bullying of the ducks, their upthrust head and thrilling cry. These have nothing to do with me. The eagle thrills to life as I do. Life is his possession. These great birds were seeking shad long before our race stepped out of the darkness of time. . . . We can destroy all this—the complex social balance that exists among animals and plants, the system that provides for inheritance and change of instinct and emotion and sensation and form—but could we invent a tree all over again, a vine, a rose, a hummingbird with a trumpet flower to fit? Can one of us design a tumblebug and teach him what to do or grow carpeting as soft as the green moss or fill an empty sky with geese and teach them Vs and honking and where to fly? Man cannot build life, for life is made with eons of time, the one missing ingredient in Man's repertoire. To him that commands time all things

are possible. To him that does not, let him stand in awe of it." Credit is due the ***Saturday Review*** for printing Etter's comment. How much space would it have received in ***Fortune Magazine*** or *Time Magazine?*

The alternatives offered conservationists are too extreme. Perhaps a solution would be to put Dr. Etter's philosophy to work as the spirit of a resource program devised to include the practical requirements of a technological civilization. There is lip service paid to this spirit by some agricultural and mining organizations who are really interested in perpetuating exploitation; and, in contrast, there are impossible demands by some naturalists for provision against any and all taking of animal life. It is the unified behavior, the health of the interlocking directorate of living things that matters. This is why the state of the wildlife community will always signalize the health of the land and the future of productive enterprises. Every resource-using and manipulating group is primarily interested in the sustained harvest of a few specific minerals, or species of organisms, sometimes wild, sometimes domestic, but which are always profoundly interrelated with scores and hundreds of so-called "useless" wild creatures. There is no need to labor this point. Modern ecology has provided abundant examples of chain reactions, of the meaning of equilibrium in nature, of the web of life. The implication that has not always been made clear is that the so-called "nature-lovers" assumed this from the beginning. Historically, they figure greatly in the conservation movement, and conservation will never get along without the hobbyists, gardeners, and sportsmen. They constantly oppose the assumption that nature is only resources, or that only resources in nature are valuable. Theirs has been an inspired, intuitive, even emotional force, calling on esthetic and spiritual values, anticipating practical and scientific proof.

Of the two great conservation problems facing Americans—a population explosion and the poisoning of our environment—the second is a question of our direct action in nature. It is amenable only to an approach which does not deal piecemeal with resources. The biochemistry of this corruption is much too fundamental to isolate itself in soil, water, or wildlife. Pollution is just as much a product of capsule thinking in conservation as it is of exploitive disregard for the future and the habitat.

Our environment continues to become a more poisoned place. The self-cleansing capacity of the air, water, and soil, is all that has saved us from the fate of a yeast population in a vat of cider—where it manufactures alcohol until it poisons itself. Mere diffusion and dilution would long ago have ceased to absorb our production of toxic wastes were there not compensatory, purifying natural machinery.

According to the Department of Agriculture, we are still adding silt to the air and to streams in volumes comparable to the 1930's. Erosion is not only a problem of topsoil loss, it is a pollution problem. There is serious doubt expressed by the U. S. Department of Public Health that the self-cleansing ability of the atmosphere will stand up under additional industrial wastes. Our larger cities now wear a permanent gray cap of toxic gases and materials in suspension. These substances are chemically active and subject to transformation by radiation, as vividly indicated in the annals of recent outbreaks of respiratory ailments. Aside from the enormous bulk of combustion residue there are organic materials from the plastics and other industries, and volatile acids which kill vegetation as well as animals. The country is 6600 municipal sewage units short and lacks 3500 industrial units. Oil on the sea kills thousands of sea birds and other life. Added to the soil and water, as well as the air, we now have continuing use of the traditional metallic poisons, plus the new organic insecticides, the chlorinated hydrocarbons, such as DDT, and the organic phosphates, such as parathion. The latter are so powerful that in pure form the minimum dose to kill a rat cannot be measured. DDT, which promised ten years ago to rid every dairy barn of houseflies, is no longer being used around dairies partly because the flies have become immune, but mostly because it accumulates and its toxicity is undiminished after passage through the cow in whose milk it appears. It is now annually sprayed over cities from New Haven to St. Louis to kill bark beetles and has been blanketed over extensive forest areas in the West and North. The pollution of the atmosphere as high as 40,000 feet has taken a new twist with the radioactive residues of nuclear explosions, debris which comes down with gravity, with rain, and with dust. Unlike the other poisons, this new one yields inheritable effects. But like them, it is defined not as something new or different in our environment, but dangerous because of its concentration. In fact, the concept of a threshold dosage, the maximum permissible amount that a human can take without pathological symptoms is the crux of a score of running controversies, from the consumption of DDT in meat and vegetables to the absorbtion of Strontium-90 from fallout.

The defect in the expiatory thinking behind a "maximum safe dosage" is first that the more we know the more it is revised downward. A "safe" dose of DDT yesterday may poison our livers tomorrow. "Safe" roentgens received by X-ray technicians earlier are now known to have increased their chances of defective offspring. Secondly, it is wrong because it idealizes life with only its head out of water, inches above the limits of toleration of the corruption of its

own environment. Why should we tolerate a diet of weak poisons, a home in insipid surroundings, a circle of acquaintances who are not quite our enemies, the noise of motors with just enough relief to prevent insanity? Who would want to live in a world which is just not quite fatal? Under such conditions we might welcome the final modicum which pushes us over the brink.

The third and perhaps most important weakness in the concept of a "maximum permissible dosage" is evident in the question, "dosage for whom?" What is the maximum safe dose for the bacteria which live in the soil, whose numbers and manifold activities there are essential to the life of the soil? What is the maximum safe dose for the insect- and therefore insecticide-catching swallow, which may not be essential to the soil, to the air, or to human activity? To base the concentration of poisons on the levels which man and his domestic plants and animals can tolerate could mean, in the coming world of chemical technology, the climax of the drama of separating the "useful" from the "useless." Even Noah did not presume to exclude any species from the ark.

The middle ground between that fringe element who would insist that we share our tomatoes with every worm in the garden and those who engineer the natural world out of existence requires a new conservation approach. It admits acceptance and enthusiasm for the triumphs of human ingenuity, taken with the understanding that the capacity to get into trouble is thereby increased. It requires a new unit of thinking about the subject matter with which conservation deals. Production techniques—agronomy, silviculture, mainstream engineering, predator and pest control—none in the past has been characterized by what Albert Schweitzer has called a "reverence for life." The most severe critic of the notion that these pursuits fulfill the needs of conservation is Joseph Krutch, who says, "What is commonly called 'conservation' will not work in the long run, because it is not really conservation at all but rather, disguised by its elaborate scheming, a more knowledgeable variation of the old idea of a world for man's use only." Yesterday toadstools had no value, except for their weird beauty, appreciated only by such 'eccentrics' as Henri Fabre, the naturalist. We would just as soon have crowded them out of the fields and forests. Then it was discovered that the fungi are necessary for the root growth of trees; then that they produce antibiotics; then that their saprophytic action is important in the metabolism of the soil. My own educational experience is that young men and women being trained as engineers, foresters, farmers, or wildlife managers would not admit to their colleagues or teachers that they enjoy the beauty of the 'useless' creatures around them, or that these

are of any real importance in the execution of their profession. After a few years many of them adopt the specious and convenient fiat of dividing nature into blacks and whites.

One sympathizes with the Dow Chemical Company official who said in a speech not long ago that he would like to withold every chemical from the market until every possible effect upon all organisms was known, but that mechanical brains had calculated the amount of research necessary and found it prohibitive. So some industries feel exonerated by making confessions of good will, by energetic experimental testing, and by the presence of the word, CAUTION, in large print on the label. But their responsibility really lies in areas as large as continents. Any reasonable person knows that we will continue to use chemicals; but, whether they like it or not, the responsibility of the makers and the users does not end in the test plot or with its effect only on crops. Although we cannot know all the possible effects we do recognize the symptoms of a natural community that is sick or a watershed in difficulty. The president of another large chemical company, the Thompson Chemicals Corporation, had this to say, "We have decided to withdraw entirely from the production, distribution, and research of the *presently known* AGRICULTURAL INSECTICIDES.

"A twelve-year study has convinced us that the currently known and used broad spectrum insecticides and their wide-scale application to agricultural crops—although giving temporary control and temporarily increased yields—are at best palliative, and perhaps will prove dangerous and uneconomic in the long run.

"The growing number of insect pests of economic importance that are becoming resistant to presently used agricultural insecticides demonstrates a serious inherent danger in the wide-scale use. The imbalance of the fauna population caused by the destruction of the natural predators and parasites (thus allowing the uninhibited development of the insect pest) is further proof to us of the unsoundness of the current chemical insecticides. This cannot only result in rapid and dynamic developments of the insect pest from the few not controlled by the application, but can easily cause heretofore unimportant insects to increase to the status of economic pests, once the predator-parasite balance has been upset.

"The ingestion of presently employed insecticide residues by humans and other warm-blooded animals is a correlative problem of a *highly serious* nature. The industrial hazards inherent in the indiscriminate, wide-scale application of chemicals of such highly toxic nature also causes concern."

The uninhibited movement of poisons in currents of air and water, and their accumulation over periods of time makes the health of the landscape itself and the survival of whole populations a basic crite-

rion of danger. Such broad units of the environment are the obligation of manufacturers of poisons and of the people who use them. And the same is true of public officials in the dispersal of city sewage and fumes; their responsibility does not end at the city limits.

It seems reasonable that a middle ground between the fanatic wearing of masks to keep from killing gnats and the imperious destruction of nature requires the prevention of extinction of any species, the maintenance of areas with natural vegetational types as cleansing filters of air and water, and the safeguarding of natural processes which tend to dampen the wobbling of natural populations or the accumulation of poisons. Aside from controls, mandatory or voluntary, on contamination of the habitat, and on population increase, a two-fold land commitment objective is indicated. One is an agriculture which insures that at least one-fifth to one-quarter of the land is always under the cover of perennial vegetational types suitable to that climate and soil. This does not mean perpetuation as 'wild' land. It would mean, for example, that in most of the eastern and southern United States that at least twenty of every hundred acres should be under forest cover. The other objective has to do with natural areas. It may be true, as the man from the chemical company says, that we will never completely understand the ecology of a natural community. But this does not discourage us from continuing to learn. If one accepts the premise that our productive enterprises are inextricably enmeshed with wild nature, from the micro-habitat of the soil to the hydrological cycle, then it would be foolish to not preserve islands of totally unhumanized landscape. The scientific natural area concept is now about fifty years old in this country. In spite of the fine work by the Ecological Society and the Nature Conservancy in that time, it has not been taken seriously by many professionals in education or resource management and has scarcely been heard of by the general public.

Momentum for preservation of natural areas, for study of the interactions of organisms, and the processes which dissipate of poisons, was associated with the National Park movement. William Cullen Bryant, George Catlin, Frederick Law Olmsted, Cornelius Hedges, George Bunnell, Nathanial Langford, and Henry Thoreau gave us a new concept of land preservation based on a love of natural scenery, solitude, and the conviction of an underlying natural order. The exploration of this order is only now begun. Yet, even today, the National Park Service appears to have failed to grasp the full significance of this aspect of the national parks, and conservation groups are constantly fighting to save areas from the agency established to protect them. The wilderness areas of the National Forests are also valuable as remnants of the natural community, but are largely accidental as remnants. We have no legislative or legal assurance, no way of being sure

that, given time, money and pressure from industry, these relic roadless areas of the national forests will not be developed. Many aspects of the natural complex can be studied on these remote areas, and they protect several species from extinction. They contribute, perhaps, to human sanity as retreats for recuperation and perspective. But the national parks and forests represent very few of our many types of natural habitat. In the West their soils are thin, their climates severe. It is just as important to have undisturbed land on the richest soils of Iowa and Illinois as it is at timber line. One of our projects at Knox College is the reconstruction of a unit of native prairie. It takes genuine conviction to remove 400-dollar-per-acre land from cultivation, but we believe that there is no other index to the strain which farming and mining are putting on northern Illinois, as good as the stable, original community which is the most efficient expression of natural process.

It is crucial that we realize that one of the most important uses of nature in the world we dominate is simply nature being itself. To some degree we can attempt to reconstruct such communities. But the fate of some still-wild areas hangs in the balance. We can and should preserve parts of Alaska and of the Sea. The 'best use' for certain areas of these frontiers would be to learn from them rather than extracting from them or heaping our wastes upon them. Many of us share toward these areas certain convictions, admitting, with E. B. White, that we are moved primarily by our feelings. Mr. White recently wrote in the *New Yorker*:

"I see by the paper this morning that a steel drum containing radioactive sodium waste is floating at sea. . . . The news story says the Atomic Energy Commission has 'authorized' the dumping of radioactive sodium waste in the ocean. I sometimes wonder about these cool assumptions of authority in areas of sea and sky. The sea doesn't belong to the Atomic Energy Commission, it belongs to me. I am not ready to authorize dumping radioactive waste into it, and I suspect that a lot of other people to whom the sea belongs are not ready to authorize it, either."

From Mr. Murray's respect for invisible microbes to Mr. White's comments on the sea, there is a wide range of conviction that nothing in nature is unimportant or useless. Our careless disposal of wastes and our zealous use of chemical poisons reveals that many people do not share this view and that compartmentalized conservation cannot deal with it. A reasonable middle ground between nature protection and exploitation includes among other things the reservation of representative natural landscapes as a margin of safety and against which to gauge the danger or success of our use of nature.

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VITAMIN C SPRAY PROTECTS PLANTS AGAINST SMOG DAMAGE

Vitamin C sprays may be one answer to the multi-million dollar smog damage to agriculture.

After six months of preliminary field testing, two University of California scientists reported that light application of ascorbic acid sprays prevented the burning and bronzing of leaves usually caused by the airborne oxidants in smog.

The spray also appears to increase the nutritive value of the crops. Plants tested include lettuce, celery, pinto beans and petunias, while spray tests are now underway with orchids, roses, carnations, alfalfa, spinach and endive.

Plant cells already contain vitamin C and related compounds which seem to help resist oxidant damage. The compounds work either directly, by destroying the toxic materials introduced with smog, or indirectly, by reversing the poisons' damaging effects on vital cell processes. Spraying increases the plant's ability to "fight back" against air pollutants.

The main significance of the success in field use of vitamin C is the demonstration that man can govern the effects on living cells of selective toxic agents in the air.

The University research is part of the statewide Air Pollution Research program being conducted here and was supported in part by funds from the Charles Pfizer Company.

NEW ANTIBIOTIC STOPS BRAIN-KILLING FUNGUS

A new antibiotic that can stop a fatal brain-killing fungus disease has been reported.

The antibiotic, called amphotericin, is still under investigation and not yet available for general use.

It was used against cryptococcal meningitis, a highly fatal fungus disease that can attack any part of the body although it shows a special attraction to the brain and its covering membranes.

The disease is caused by a fungus found in all parts of this country. It gets inside the body, creating abscesses that can resemble either cancer or tuberculosis.

Six victims of the disease were given intravenous injections of amphotericin B and five are still alive after follow-up studies ranging from five to 10 months.

In three of them, all the symptoms of the disease have disappeared and they have resumed normal activities.

THE STATUS OF SPECIAL GRADUATE COURSES FOR THE HIGH SCHOOL CHEMISTRY TEACHER

W. G. KESSEL

Associate Professor of Chemistry, Indiana State Teachers College, Terre Haute, Indiana

The present shortage of adequately trained chemistry personnel has focused attention upon a situation that has long needed some special consideration; namely, the inadequacies of our present teacher-training program for the secondary chemistry teacher. Perhaps one should say situation, instead of shortage, for some recent studies suggest that there is no shortage. However, the amazing parade of statistics revealed through various media of communication indicate that too many of the figures are glibly reported as truth when they were taken out of context or misread, as well as missued and misunderstood.

Perhaps we often feel like Mark Twain's comment, "'Twasn't my ignorance that done me in; 'twas the things I knowed that wasn't so." If you have read T. M. Stinnett's article, "Check that Statistic!", pp. 83–90 in the April 1957 *Educational Record*, you will be aware of this phenomena that is too often encountered in educational work.

Even so, the present and future requirements for scientific personnel, pin-pointed by the recent fiascos, will surely put more and more pressure upon our secondary science departments.

The necessity for additional schooling beyond the Bachelor's degree also has forced many secondary teachers into the graduate schools. Traditionally, they have followed one of two patterns—work in their particular discipline or work in education.

The chemistry teachers have accepted this pattern in setting up their graduate programs. Those who decide to continue in chemistry have been those individuals with the conventional undergraudate major in the field. Consequently, they have completed the necessary prerequisites for the traditional graduate curricula. The number in this category has been relatively small; usually it has included those who are contemplating college or university teaching, those who are considering shifting to industry, and most important the enthusiastic, dedicated individuals who want to give the most and the best chemistry to their pupils.

Realistically, other teachers have faced the fact that chemistry at this level is more expensive, time consuming and difficult. So, when the decision about their program in graduate school was made, they did not take chemistry. It is quite appalling to individuals not familiar with secondary schools to learn that most salary schedules accept the Master's degree at the same value regardless of the discipline in which it was earned.

Those of us in chemistry, a field which has changed so amazingly through the years, where enough new information is produced yearly to require more than twelve years reading time at eight hours per day, seven days per week, feel that some graduate chemistry is imperative. The high school teacher cannot know it all, but he must be enough up-to-date to maintain the respect of his students as well as to help them see chemistry's increasing potential.

The erstwhile chemistry teacher, then, often enrolls in graduate school and majors in education. One must realize that the chances for advancement in schools today is almost uniformly achieved when one gives up teaching and becomes an administrator. It takes only a little investigating to show that the majority of holders of Master's degrees have done their work in administration, not teaching. Too many chiefs—not enough Indians!

According to information collected in this study, the graduate student in education almost always has some selectivity in the courses he may take. So, it might appear that the chemistry teacher should and would elect some chemistry. But, relatively few institutions will allow him to take work he really needs or provide him with the opportunity to engage in special courses designed for his problems. There are some colleges and universities where graduate credit is given for the taking of regular undergraduate courses, if the teacher shows a need of them.

The purpose of this investigation made by the Committee on the Teaching of Chemistry of the Division of Chemical Education of the American Chemical Society was to identify institutions where specially designed courses were available for the high school chemistry teacher. This committee felt that such information would be helpful to the high school teacher and might also stimulate colleges and universities to contemplate and develop more satisfactory courses for these people.

It must be realized that this is no complaint against the conventional graduate program of chemistry. There is ample evidence of its success, but too few of the candidates we are considering can follow such a procedure. The secondary teacher has a diversified background and in his first jobs may teach several subjects; consequently, his undergraduate work in a specific subject matter field is often somewhat sketchy.

Many institutions feel that this is no excuse, and the teacher should follow the old tradition. However true, such a feeling does not fit the situation, for the teacher cannot see the advantage of considerable make-up work to qualify with needed prerequisites. Remember that the salary schedule will not recognize the make-up work of the area of the degree.

The 1956-57 Education Directory of the United States Department of Health, Education and Welfare lists 426 colleges and universities that offer a Master's or a second professional degree. However, only 323 of these schools have a Dean of the Graduate School or a special Graduate Division. The committee sent their inquiry to these schools and obtained 201 answers along with numerous comments. Information concerning an additional 59 schools was obtained from a variety of published material.

Twenty-five of the 260 schools surveyed in this fashion did not offer a Master of Arts, a Master of Science, or a Master of Education degree. Of the 235 other schools (all of which offer some type of Master's degree program for in-service science and mathematics secondary teachers) there are 28 schools offering a program that is sufficiently different to be classified as "special degree programs for in-service science and mathematics teachers in the secondary schools."

This is the list of the "special programs available.

University of Arkansas	M.S. in Natural Science
University of Denver	M.A. in General Science
Wesleyan University (Conn.)	M.A. in Liberal Studies
American University (D. C.)	No special title
Catholic University (D. C.)	M.S. in Teaching
Emory University (Ga.)	M.A. in Teaching
Illinois Wesleyan U.	M.S. in Science Teaching
Indiana University	M.A. in Teaching
Notre Dame University	M.S. in Teacher Training Program
University of Iowa	M.S. in General Science
Eastern Michigan College	M.A. in Teaching General Science
Michigan State University	M.A. in Teaching
University of Mississippi	M.S. in Combined Science
St. Louis University	M.S. in Teaching of Chemistry
New Mexico Highlands University	M.S. in Science Education
Rensselaer Polytechnic Institute	M.S. in Natural Science
University of Buffalo (N. Y.)	M.S. in Natural Science
Duke University (N. C.)	M.A. in Teaching
Antioch College (Ohio)	M.S. in Teaching
Miami University (Fla.)	M.A. in Teaching
Oklahoma State University	M.S. in Natural Science
University of Oklahoma	Master of Natural Science
University of Texas	No special title
Brown University (R. I.)	M.A. in Teaching
Washington State	M.A. in Teaching
University of Wisconsin	M.S. in Science Education
University of Puerto Rico	M.S. in Science Education
Drake University (Iowa)	No special title

Thirty-six other colleges and universities are utilizing their existing degree programs which include a number of "tailored" courses designed to meet the secondary chemistry teachers' needs. The list follows:

Alabama College
College of the Pacific
Loyola of Los Angeles
Colorado State College
University of Colorado
University of Bridgeport (Conn.)
University of Connecticut
Northeast Missouri State Teachers College
Montana State College
Brooklyn College
Canisius College (N. Y.)
College of St. Rose (N. Y.)
Cornell University
University of Delaware
Stanford University
University of Chicago
Western Illinois State College
Kansas State Teachers College
University of Kansas
University of Maryland
Boston College
Clark University (Mass.)
Western Michigan University
University of Minnesota
Syracuse University
University of North Carolina
Oregon State College
Bucknell University
East Tennessee State College
Vanderbilt University
North Texas State Tech. College
University of Vermont
Central Washington College of Education
Marshall College (W. Va.)
University of Wyoming

The above lists are the result of somewhat arbitrary evaluation on the part of the committee as to what constitutes a special program for in-service secondary school science teachers

In addition to these 63 schools that have some sort of program for in-service science teachers, there were 15 colleges and universities which are in the active working stage of producing such a program. Eighteen additional schools indicated they are "thinking and planning." Eighty-three replies stated that they were interested in such a program but had no plans for implementing one at their school. Only 55 replies evidenced no real interest in changing from conventional existing programs. Very few were overtly antagonistic to the "special programs."

The schools represented in the survey were from every state, the District of Columbia, Hawaii, Alaska and Puerto Rico.

All who have engaged in surveys of this type are aware of the fact that one does not always get all the desired information. Doubtless, there are some colleges and universities with a fine program of this nature in operation, but for one reason or another the committee did not receive any reply about it.

A great many revealing and interesting comments accompanied the return of the questionnaire. The following statements were selected as they express some of the constant recurring opinions.

"We have long recognized at the University of———the problem posed in your letter."

"It is difficult to get advisors in education to plan students' programs to include these courses."

"Our major effort for 'in-service' science teachers is the Summer Science Insitute."

"The real stimulus, here of course, has been due to American Academic Year Institute. We plan . . . ."

"Unquestionably we help our science students very greatly—many of them never had solid courses in science and mathematics before coming here. The program is unpopular with our own science faculty who feel it to be perilously close to dishonesty to call such elementary courses graduate work."

". . . and trust too, that the open sesame of a master's degree in education will not be required for advancement but rather that the in-service training and interest of the teacher will be the prime consideration rather than the degree."

"If the work taken by the student is to apply to a graduate degree, it must have at least some of the elements of graduate work. These elements are not in an introductory course in a field—this poses a pracitcal problem."

"We are in the process of trying to convince . . . that the MAT is desirable and necessary. It will take a little more time."

"I would strongly oppose the granting of graduate credit for freshman and sophomore courses for this simply downgrades the master's degree. There is too much emphasis on degrees and not enough on how much he knows."

"This allowance of graduate credit for undergraduate work at first was slow to attract attention."

"The first course in a field is not necessarily at the freshman or sophomore level—it may have similar content but freshmen and sophomores are not permitted to take these courses designed for teachers."

"Our Graduate Council has held to the idea that graduate work for teachers should be no different from graduate work for others. . . ."

". . . until the public schools offer some sort of salary competition with industrial firms. . . ."

". . . next idea we are playing with somewhat coyly . . . is to see whether it is humanly possible to develop general courses in the sciences that could be given in a respectable fashion on the graduate level."

"Education is not measured by the aquisition of academic degrees. . . ."

"It is my firm belief that special courses must be designed to upgrade the teaching of secondary school science."

"Unwillingness of academic departments to offer suitable courses causes teachers to select the available courses in education. This many of us regret . . . can you do something to encourage chemistry departments to offer flexible chemistry courses. . . ."

". . . do not have a special program for teachers and do not look with favor on such discriminatory practice."

In summary this survey indicates that:

1. Many colleges and universities are aware of the difficult problem of developing a more satisfactory training program for the high school chemistry teacher at the graduate level. The techniques in common use now are:
   a. A National Science Foundation sponsored summer and/or year program tailored especially for the teachers in specific areas of science.
   b. The development of their own institutes or workshops to meet their own students' needs.
   c. The creation of special courses, as part of their regular program, that recognize the particular inadequacies and unique problems of the high school science teacher.
2. A continuing conflict, although less bitter than in the past, still exists between chemistry and education. Considerable evidence of satisfactory compromise by those involved is apparent in some of the present programs. Of those reporting, the majority have their degree based upon one half of the courses in subject matter and one half in education. The range, however, is from no subject matter to all subject matter and from no education to all education. Sixty-six and two-thirds per cent subject matter and $33\frac{1}{3}$ per cent education is the other most common ratio.
3. Some institutions are quite concerned with the small enrollment in graduate courses that were created for high school science teachers. They attribute this to (1) the financial advantages of working in industry; (2) the trend to administrative work; and (3) lack of interest and enthusiasm for science.
4. There is a wide divergence of opinion on the question of giving graduate credit for the beginning courses. Nevertheless, many are giving credit for upper division work (junior and senior courses) and some even for freshman courses in the field of chemistry if the student had had no undergraduate work in the field.

Committee:

W. B. Cook, Chairman, Montana State College, Bozeman, Montana
L. B. Clapp, Brown University, Providence, Rhode Island
L. H. Colburn, Taylor Allerdice High School, Pittsburgh, Pennsylvania
Dorothy W. Gifford, Lincoln School, Providence, Rhode Island
W. G. Kessel, Indiana State Teachers College, Terre Haute, Indiana
T. C. VanOsdall, Santa Ana College, Santa Ana, California

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2576. *C. W. Trigg, Los Angeles, Calif.*

2596. *Emma Jacobus, Pensacola, Fla.*

2596. *Mabel Peaslee, Fort Plains, N. Y.*

2599. *Nellie Roberts, Valley Stream, N. Y.*

2599. *Nina Hunt, Vale, Oregon.*

2602. *Walter R. Warne, St. Petersburg, Fla.*

2413. *No correct solution has been offered.*

2424. (May 1956) *Proposed by Joseph Kennedy, Madison, Wis.*

It is observed that the totals which may be made by three dice may be made in the following number of ways:

Total	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No. of Ways	1	3	6	10	15	21	28	36	36	28	21	15	10	6

These numbers occur in the diagonal of the Pascal Triangle beginning at one end of the third row.

$$\begin{array}{ccccccccc} & & & & 1 & & & & \\ & & & 1 & & 1 & & & \\ & & 1 & & 2 & & 1 & & \\ & 1 & & 3 & & 3 & & 1 & \\ 1 & & 4 & & 6 & & 4 & & 1 \end{array}$$

etc.

It is further observed that the diagonal beginning at the end of the nth row seems to give the number for n dice. Why does this happen?

EDITOR'S NOTE: LeRoy Warren, San Diego, Calif. points out that a total of 9 may appear on three dice in 25 ways only, hence the problem, as stated, is incorrect.

2456. (December 1956) *Proposed by Howard D. Grossman, New York, N. Y.*
Prove (a) the sum of the areas of any three faces of a tetrahedron is greater than the area of the fourth face; (b) the plane area bounded by a broken line (or curve) in a plane is the smallest area bounded by that curve.

Solution by P. W. Shaw, San Diego, Calif.

(a) Let the base have area A_4, and the other sides have areas A_1, A_2, A_3, respectively. Project these areas on the base plane. Then

$$\text{Proj. } A_1 + \text{Proj. } A_2 + \text{Proj. } A_3 \geq A_4,$$

i.e.

$$A_1 \cos\alpha + A_2 \cos\beta + A_3 \cos\gamma \geq A_4.$$

But

$$|\cos\alpha| \leq 1, \qquad |\cos\beta| \leq 1, \qquad |\cos\gamma| \leq 1,$$

therefore

$$A_1 + A_2 + A_3 \geq A_4,$$

actually the sum is greater than A_4, since at least one of $\cos\alpha$, $\cos\beta$, $\cos\gamma$ is less than 1.

(b) The same reasoning proves that the area bounded by a plane curve is least when the area is a plane since this area is at least equal to the projection of any surface of the plane.

2547. *No correct solution has been offered.*

2553. *No correct solution has been offered.*

2583. *No correct solution has been offered.*

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

EDITOR'S NOTE: This department has a need for some new and interesting proposals. Please send in some problems to the Editor.

PROBLEMS FOR SOLUTION

2623. *Proposed by Lowell T. Van Tassel, San Diego, Calif.*
A mathematical marksman takes a pot-shot at a one inch cube. Assume the bullet trajectory to be a straight line, and to pierce the target. If the cube is randomly spun before it is tossed into the air, what is the probability that

(a) any two adjacent faces will be pierced?
(b) any two parallel faces will be pierced?
(c) Does PR (a)+Pr (b)$=1$; i.e. are (a) and (b) exhaustive, assuming the cubical target to be hit?

2624. *Proposed by C. W. Trigg, Los Angeles City College.*

Each of the letters in (FB) $(CA)=(BA)$ $(DC)=EEE$ uniquely represents a digit. Decode the problem.

2625. ***Proposed by John Satterly, Toronto, Canada.***

If I is the incenter of triangle ABC with sides a, b, and c, prove

$$a\cdot IA^2+b\cdot IB^2+c\cdot IC^2=abc.$$

2626. ***Proposed by A. R. Haynes, Tacoma, Wash.***

A circle of given radius passing through the focus, S, of a given conic intersects it in A, B, C, and D. Show by means of polar equations $SA\cdot SB\cdot SC\cdot SD$ is a constant.

2627. ***Proposed by L. M. Ridder, Exeter, N. H.***

Evaluate

$$\cfrac{1}{1+\cfrac{2}{1+\cfrac{3}{1+\cdots}}}$$

2628. ***Proposed by Bolton Davidheiser, Escondido, Calif.***

If d different digits are used in making all possible numbers of n digits (the digits may be repeated), then the number of occurrences of any particular arrangement of r digits is

$$d^{n-r}(n-r+1)$$

BOOKS AND TEACHING AIDS RECEIVED

MATHEMATICAL EXCURSIONS, by Helen A. Merrill. Paper. Pages xi+145. 14×20.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.00.

TEACHING CHILDREN TO DIVIDE, by Henry Van Engen and E. Glenadine Gibb. Paper. 23 pages. 15×23.5 cm. 1958. Educational Service Publications, Iowa State Teachers College, Cedar Falls, Iowa. Price $.20.

GALILEO AND THE MAGIC NUMBERS, by Sidney Rosen. Cloth. 212 pages. 14.5×21.5 cm. 1958. Little, Brown and Co., 34 Beacon St., Boston 6, Mass. Price $3.50.

COLLEGE PLANE GEOMETRY, by Edwin M. Hemmerling, *Bakersfield College*. Cloth. Pages ix+310. 14.5×23 cm. 1958. John Wiley and Sons, Inc., 440 4th Ave., New York 16, N. Y. Price $4.95.

THE FETAL PIG, A Photographic Study, Rev. Ed., by W. L. Evans, *The University of Arkansas;* Paper. Pages iv+44. 18.5×25 cm. 1958. Rinehart and Co., Inc. 232 Madison Ave., New York 16, N. Y. Price $1.25.

PUZZLE-MATH, by George Gamow and Marvin Stern. Cloth. 119 pages. 14×20.5 cm. 1958. The Viking Press, Inc., 625 Madison Ave., New York 22, N. Y. Price $2.50.

INSTRUCTIONAL MATERIALS FOR MATHEMATICS CLASSES, by Kenneth P. Kidd. Paper. 32 pages. 15.5×23 cm. 1958. Materials Diffusion Project, College of Education, 317 P. K. Yonge Bldg., University of Florida, Gainesville, Fla. Price $.40.

A TREATISE ON PLANE AND ADVANCED TRIGONOMETRY, by E. W. Hobson. Paper. Pages. xv+383. 14×20.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.95.

GENERAL GEOLOGY LABORATORY WORKBOOK—Physical Geology and Historical Geology, Edited by Samuel P. Ellison, Jr. Paper. Pages x+285. 20.5×28 cm. 1958. Harper and Bros., 49 E. 33rd St., New York 16, N. Y. Price $3.75.

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GEOMETRICAL DRAWINGS FOR STUDENTS, by Richard Marriott, *Head of Technology Department, Mansfield Secondary Technical School, England.* Cloth. 112 pages. 14×21.5 cm. 1958. Methuen and Co., Ltd., 36 Esses St., London, W. C. 2, England. Price 7s 6d.

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LEARNING TO USE ARITHMETIC, BEGINNERS BOOK, by Agnes G. Gunderson and George E. Hollister. Paper. 64 pages. 21×29 cm. 1958. Price $.64.

TEACHERS EDITION to accompany above. 65 guide pages+64 pages. Price $.64.

LEARNING TO USE ARITHMETIC, BOOK 1, by Agnes G. Gunderson and George E. Hollister. Paper. 96 pages. 21×29 cm. 1958. Price $.76.

TEACHERS EDITION to accompany above. 97 guide pages+96 pages. Price $.76.

LEARNING TO USE ARITHMETIC, BOOK 2, by Agnes G. Gunderson and George E. Hollister. Paper. 160 pages. 21×29 cm. 1958. Price $1.00.

TEACHERS EDITION to accompany above. 161 guide pages+160 pages. Price $1.00.

LEARNING TO USE ARITHMETIC, WORKBOOK 3, by Joseph H. Randall. Paper. 144 pages. 21×29 cm. 1958. Price $.92.

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BOOK REVIEWS

TRIGONOMETRY, by Rolland R. Smith, *Co-ordinator of Mathematics, Public Schools, Springfield, Mass.*, and Paul P. Hanson, *Head of Mathematics Department, The Manlius School, Manlius, N. Y.* Cloth. Pages x+470. 15×23 cm. 1957. World Book Company, Yonkers-on-Hudson, N. Y.

Trigonometry contains most of the material usually considered to be essential in a traditional plane trigonometry course. However, the method of organization is unusual for a textbook of this kind.

The book is divided into six chapters and each chapter is sub-divided into several lessons. Each lesson covers an important topic and, according to the authors, is of suitable length to be covered by an average class in a single class period. There is a total of eighty such units with nineteen labelled as optional. In addition some topics and exercises within each lesson are also labelled optional. By omission of the optional materials the teacher could teach a minimum course for average students and use the additional material to handle a wide range of student abilities and meet other requirements.

Each lesson is introduced by a set of preparatory exercises designed to provide a review of mathematics previously covered that is essential for an understanding of the lesson. This is followed by a discussion of the topic and several illustrative examples. The lessons are concluded with an ample number of exercises to permit selection by the teacher as student ability and time may allow, as well as review exercises selected to emphasize important concepts within the immediate and previous lessons.

All of the drawings and graphs are clearly labelled and easy to follow.

The average student should experience little difficulty in understanding the text material, or in working most of the exercises, with a minimum of assistance from the teacher.

J. BRYCE LOCKWOOD
Highland Park Junior College
Highland Park, Michigan

PRINCIPLES OF PHYSICAL SCIENCE, by Francis T. Bonner, *Arthur D. Little, Inc.;* and Melba Phillips, *Washington University*, Cloth. Pages xvi+736. 15×23 cm. 1957. Addison-Wesley Publishing Co., Inc., Reading, Mass. Price $7.50.

This textbook is written for use in a one-year course in college physical science. It is designed for the liberal arts student who does not have a special interest in science and whose contact with science probably will be limited to a single course. However, there is sufficient depth in the treatment of many topics to interest science students and, in many cases, ta-the ability of non-science students.

The authors have attempted to avoid a survey-type course that may necessarily mean a sacrifice in depth. On the other hand, they have also tried to avoid a strictly historical approach. Most of the historically significant theories have been presented together with the principles generally considered to be important from the fields of astronomy, physics, chemistry, and geology.

The textbook begins with a historical treatment of theories dealing with the solar system, followed by three chapters dealing with Newtonian mechanics. The next five chapters are concerned with the structure of matter and important laws. One chapter deals with momentum, work and energy, followed by a single chapter on heat and the conservation of energy. Two chapters are then presented that treat such topics as the gaseous state and the kinetic theory with revision of the ideal gas equation for real bases. Two chapters are devoted to electricity and magnetism. These are followed by a chapter on wave motion and one on light as a form of wave motion. Three chapters deal with atomic structure, the periodic table and chemical bonds. Three more deal in succession with matter in solution, chemical equilibrium and organic chemistry. Physical and historical geology are then treated in three chapters. The book is concluded with a chapter on nuclear processes and one on stars and galaxies.

The appendix of the book includes a review of techniques of mathematics and measurement including proportionality, units, graphs, exponential notation, angular measure, and triangulation. These should be helpful to the student in working the numerous exercises and problems presented at the end of each chapter.

According to the authors, the textbook is designed for the college freshman with a knowledge of elementary algebra. This reviewer believes that students with this minimum may experience some difficulty in comprehension of all of the mathematical manipulations used in the derivation of equations in the text material to say nothing of the mathematics needed for successful completion of all the problems and exercises.

It is the opinion of this reviewer that, the authors in their attempt to avoid a survey-type course that lacks depth, have surveyed the fields of astronomy, physics, chemistry and geology with a greater-than-usual amount of mathematics for the typical textbook for non-science majors. Hence, it is recommended that this would probably be an excellent supplementary textbook for any physical science course.

All of the topics presented are covered adequately so that the ambitious teacher could use the textbook advantageously by a careful selection of material suited to the level of ability of the students generally enrolled in a physica science course.

J. Bryce Lockwood

Working with Children in Science, by Clark Hubler, *Wheelock College*. Cloth. Pages vii+425. 16×23 cm. 1957. Houghton, Mifflin Company, 2 Park Street, Boston, Mass. Price $5.50.

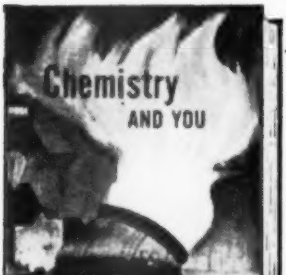
The content of this book is directed toward increased emphasis on the science areas in today's world. The author, Dr. Hubler, is a firm believer that reading about science in the elementary school is not enough. The child must experiment and investigate to get the maximum benefits from the study of science. He also believes that through science, children get a better understanding of themselves and the world about them.

This book is written for both the experienced and prospective teachers in the elementary and junior high schools. It is full of suggestions and procedures for teachers from the nursery school through munior high. It is a book which is an excellent source of reference for any teacher. It would be most helpful to supervisors and administrators who were interested in promoting a better science program in their schools.

Interesting examples are cited how science has stimulated children to read and speak effectively to others. Many processes in arithmetic computation can be stressed again in science, such as small children learning to count by 2's through the use of the thermometer. Examples of desirable and suitable science experiences for various grade levels are presented. The author tells how to accomplish the most in science when there are so many variations in background, interest, and abilities. The use of materials and available sources are listed. Many suggestions are made for the construction of simple equipment.

Chapters 8–13 furnish specific information on such units as Interpreting the Sky, Chemical Changes, The Rocks and Soil of the Earth's Surface, Experimenting with Magnetism and Electricity, and Understanding Air and the Weather. At the end of each chapter is a bibliography of suggested books and reading materials for the students.

Lucille Gross
McCalla School
Bloomington, Indiana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